REPORT

TO THE GOVERNMENT OF CEYLON

ON THE

PEARL OYSTER FISHERIES

OF THE

GULF OF MANAAR,

BY

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WITH SUPPLEMENTARY REPORTS

UPON THE

MARINE BIOLOGY OF CEYLON,

BY OTHER NATURALISTS.

PART V.

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PREFACE.

This Report on the Pearl Fisheries and Marine Biology of Ceylon has required a much greater expenditure of time and labour, and has extended to a greater length, than was contemplated at the outset. In the winter of 1901, it was supposed that about one year must elapse, after my return from Ceylon, before the Report could be completed, but the necessary work has occupied all my leisure for over four years, and I am painfully conscious that it is still unfinished—there are several matters I should like to have included, or to have followed up further, had time for investigation and funds for publication been less limited.

But this must be the final volume, and I wish now, in bringing the work to an end, to make use of this opportunity mainly for the purpose (1) of reiterating my thanks to many friends who have kindly helped me, (2) of correcting such errors and omissions* in the former volumes as have come to my notice, and (3) of saying my final word as to the present position and future prospects of the pearl fisheries.

I have reluctantly come to the conclusion that an index to the five volumes is impracticable. If it contained all specific names it would be largely an unjustifiable repetition of our lists, and every Zoologist who consults the work will be readily able to find any desired species from the classifications given in the reports. It may, however, be some aid to the reader if I give here a scheme indicating in which Part each section of the subject and each special report will be found. The sections of the pearl-oyster report proper are arranged in chronological order, as that corresponds with the natural development of the subject, from preliminaries to final conclusions, and the special, or "supplementary," reports are placed in zoological order from the lowest groups to the highest, so that the position of each in the volumes can be ascertained from this list at a glance.

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* If I may be allowed to offer the suggestion, I believe the most convenient form of reference to a species in one of these Supplementary Reports would be as follows:—*Sphæroma walkeri*, Stebbing, in Herdman, 'Ceylon Pearl Fisheries,' Part IV., p. 31, Suppl. Rep. XXIII., "Isopoda," 1905.

No. XXXIII.—On the Schizopoda and Stomatopoda	Part	V., p. 157.
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It has been my desire, so far as possible, to deposit the types of new species in the British Museum. In the case of some of the smaller forms the type specimens have become more or less used up in the process of examination, or exist only in the form of fragments on microscope slides or as sections. In other cases, the authors are still actively working at the groups in question, and it has been represented to me that the best interests of science would be served by allowing all the specimens to remain in their hands for the present. I have, however, already sent to the British Museum the types of new species, and, in some cases, representatives of additional species, in the following groups:—Echinodermata, Pantopoda, Hemiptera, Polyzoa, Cumacea, Amphipoda, Leptostraca, Schizopoda, Stomatopoda, and, in the case of other groups, the specimens are now in process of being picked out for packing and transmission.

I am very much indebted to my Zoological friends who have so ably helped me by taking charge of separate groups. The Supplementary Reports which they have contributed form a valuable body of information on the marine fauna of Ceylon which is indispensable in discussing any biological problems in that part of the Indian Ocean. A few corrections and additions kindly supplied by the authors will be found at the end of this volume.

I desire once more to acknowledge the very efficient help which I have received from Mr. JAMES HORNELL, F.L.S., both in the initial investigation and also during the production of this Report. Even after Mr. HORNELL ceased to be formally my assistant in the matter, and was appointed to a responsible post under the Ceylon Government, he continued to spare no pains to keep me fully informed of the changes in the condition of the pearl banks and to obtain any specimens or evidence that might be required to clear up points in doubt.

Since the last volume of this Report was issued, another very successful pearl fishery has been held at Ceylon. Over 67 millions of oysters were fished, and the total proceeds amounted to 1,385,000 rupees. This does not, of course, rival the great fishery of 1905 (when over eighty-one and a half millions of oysters were fished and the revenue brought in was upwards of two and a half millions of rupees), but it comes second on the list of recorded fisheries, and makes the fourth in successive years of a remarkable series—the most profitable pearl fisheries that, so far as is known, have ever been held.

As to the future, it seems probable that the remaining oysters on the Muttuvaratu Paar, along with the patches which are known to be on the Karativo Paar, on the Mid-west Cheval and on a new ground inspected by Mr. HORNELL, lying three to four miles N.N.E. of the Muttuvaratu, will suffice for a fishery of moderate dimensions in 1907. Then, in 1908, there should be a good fishery on the Mid-east Cheval, where there is now a healthy bed of two-year-old oysters, which was reinforced with 1000 tons of cultch last spring. After 1908 the prospects depend upon further careful scientific inspecting, transplanting and cultching, upon the lines which have been laid down in successive sections of this report.

It can scarcely be doubted that the aquicultural operations which have been commenced under the auspices of the Ceylon Government will be carried on vigorously by the Pearl Fishing Company to which the fisheries have now been leased. It must be a matter of congratulation to all concerned—to the Colonial Government, to the Company, and to men of science—that, in the terms of the lease, the necessity for a scientific treatment of the pearl banks during the next twenty years has been duly recognised and provided for.

After such treatment the property ought to be returned to the hands of the Government at the end of the period in a still more valuable condition than it is at present, and even if that were to be the only economic result of the present Report, those who have spent thought, time, and money in the investigation and the publication will be able to feel that their labour has not been in vain.

I cannot conclude without expressing my appreciation of the honour done me by the Royal Society in undertaking the publication of this Report, and I desire especially to thank those I have had to consult with at the Colonial Office, as well as the Officers and Staff at the Royal Society, for much kindly interest and consideration, for advice given and trouble taken during the progress of the work.

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THE UNIVERSITY, LIVERPOOL.

September, 1906.

REPORT ON THE PEARL OYSTER FISHERIES OF THE GULF OF MANAAR.—PART V.

PEARL PRODUCTION.

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[WITH THREE PLATES AND SOME TEXT-FIGURES.]

THE investigation of a pearl fishery clearly falls into two parts—(1) the prosperity of the pearl-producing mollusc as part of the population of the pearl banks, and (2) the production of the pearls. It is the latter subject to which we now come. The preceding sections of this Report have dealt mainly with the pearl oyster as a healthy animal—with its distribution, structure and mode of life; while the Supplementary Reports have made known the many organisms which are associated with the pearl oyster on the banks, and which are inter-related with it in various ways and undoubtedly influence its life and prosperity.

The present section, on the other hand, treats of an abnormal process. Pearl-formation has often in the past been characterised, with substantial truth, as "a disease"; and whether the pearly material be deposited around a parasitic worm, or upon a particle of inorganic sand, or over an organically formed calculus, the resulting pearl is in each case a pathological product of the oyster's own tissues. It is always the shell-fish itself that makes the pearl. The pearl-inducing parasite does not produce the pearl any more than the grain of sand does, but either of them can

apparently supply the stimulus which leads in the end to the formation of the gem. Many different kinds of shell-fish produce pearls, and these latter differ in quality in accordance with the animal that has deposited them rather than with the nucleus around which they have been formed. Still, even in the same shell-fish, pearls may differ much, and such differences are due to the nature of the nucleus, to the position in the body, and to the method of formation.

It is clear that pearls can be formed in several different ways, and recent discoveries show that some of the earlier suggestions are not altogether fanciful but contain an element of truth. The writings on pearl-production are numerous, and it is unnecessary to discuss all the views that have been held. But this report would have little claim to be regarded as even moderately complete if no mention were made of, at any rate, a few of the chief stages in the discovery of how pearls are formed.

HISTORICAL.

Our subject being the oriental pearl, it is only appropriate that we should mention first the early Hindu tradition, held even to the present day in the East, that at night or during heavy rain the pearl oyster ascends to the surface of the sea, opens its shell to the air and takes in drops of fresh water which become consolidated as pearls. PLINY and other classical writers record the similar belief that pearls are caused by drops of dew which enter the gaping shell at dawn and reflect the first rays of the sun, while still uncovered by the sea. Another poetical variant is that the pearls are due to the tears of the Nereids. These and other equally fanciful ideas are found scattered through the literature for centuries; and COLUMBUS, we are told, was convinced he had found the locality for orient pearls when he reached a spot, on the coast of Paria, in South America, where the trees grew down into the sea and had their roots covered with oysters gaping ready to receive the dewdrops from the leaves above.

As an example of an entirely different, but equally imaginative, idea, we have ÆLIAN'S statement that the pearls were formed by a lightning flash entering the opening shell. It must not, however, be supposed that all the views of the ancients on pearl-formation were wholly erroneous, for, as GIARD has recently pointed out, ATHENÆUS states that a certain ANDROSTHENES, who had travelled in the East, compared the developing pearls in the oyster to the Cestode larvæ in pork—a wonderfully close approximation to the truth.

Coming to more modern writers, we find many speculations as to more or less mysterious pathological effusions which may become solidified, as to displaced eggs which may form centres of deposition, as to possible similarity to calculi and to galls, and as to calcification of deposits formed around sand-grains, microscopic algæ, ova, embryos, and various kinds of minute parasites and other organic nuclei. We shall give here, in tabular form, some of the leading names (by no means a complete list) in

the history of this inquiry, with, where known, the species of shell-fish on which the observations were made, and an indication of the view held, with more or less justification, as to the nature of the nucleus around which the pearl is formed.

Author.	Shell-fish investigated.	View as to origin of pearl or nature of nucleus.
Androsthenes	Oriental pearl oyster	(?) Cestodes.
Pliny	Oriental pearl oyster	Drops of dew.
Ælian	Oriental pearl oyster	Lightning-flash.
Rondeletius, 1554	. . . .	Parasites; also concretions.
Redi, 1671	. . . .	Grain of sand.
Réaumur, 1717	*Pinna*, &c.	Pathological effusion of shell-matter.
Bohadsch, 1761	*Aplysia*	Calculi.
Sir E. Home, 1826	*Anodonta*	Abortive ova.
Filippi, 1852–56	*Anodonta*	*Distomum* (Cercaria), &c.
Küchenmeister, 1856	*Margaritana* and *Anodonta*	Mite (*Limnochares anodontæ*).
Von Hessling, 1856	*Margaritana* and *Anodonta*	Sand, algæ, ova, parasites.
Meckel, 1856	. . . .	Calculi.
Moebius, 1857	Both marine and fresh-water	Entozoa.
Kelaart, 1857–59	Ceylon pearl oyster	Sand, diatoms, ova, parasites.
Pagenstecher, 1858	. . . .	Pathological concretions.
Garner, 1863, 1871	*Anodonta* and *Mytilus*	*Distomum*.
Harley, 1889	"British, Australian and Ceylonese" oysters	Calculi round inorganic or organic particles.
Comba, 1898	*Margaritifera vulgaris*	Parasites.
Diguet, 1899	*Meleagrina margaritifera*	Pathological calcification of fluid formed around parasite.
Giard, 1897, 1901	*Donax*, *Tellina*, &c.	Distomids.
Dubois, 1901, 1903	*Mytilus* and *Margaritifera*	Distomid larvæ.
Jameson, 1902	*Mytilus edulis*	Distomid (Cercaria).
Herdman and Hornell, 1902, 1903, 1906	Ceylon pearl oyster (*Margaritifera vulgaris*)	Larval Cestodes.
Seurat and Giard, 1903, 1904, 1906	*Margaritifera margaritifera*	Larval Cestodes.
Shipley and Hornell, 1904	Ceylon pearl oyster	Larval Cestodes.
Crossland, 1905	Red Sea pearl oyster	Larval Cestodes.
Hornell, 1905	*Placuna placenta*	Larval Cestodes, rarely Distomids.

Omitting the more fanciful views, there are evidently three main methods which have been advanced as explaining the formation of pearls; and as is not infrequently the case when there are several competing theories, it cannot be said that one only is correct and of universal application and that the others are quite erroneous. The three methods referred to are:—(1) The grain-of-sand irritation; (2) the pathological secretion; and (3) the stimulation caused by the presence of a parasitic worm which acts as a nucleus, around which an epithelial sac deposits successive layers of pearly material. We shall briefly examine each of these views in turn.

Most of the attempts* at artificial "margarosis"—the production of pearls by stimulation of the Mollusc—have been based upon the belief that the nucleus of the

* There is, however, another artificial method which has been suggested—by infection with the parasites—which will be discussed below.

natural pearl is an inorganic particle. This "grain-of-sand" theory was supported by REDI and many other early and also more recent Naturalists, and it is the view which has been most generally adopted in the text books, and perhaps we may add in educated public opinion, as expressed, for example, in Sir EDWIN ARNOLD's lines :—

> "Know you, perchance, how that poor formless wretch—
> The Oyster—gems his shallow moon-lit chalice ?
> Where the shell irks him, or the sea-sand frets
> This lovely lustre on his grief."

Of late years, however, this view has been discredited by scientific investigators, and some recent writers seem to exclude altogether the grain of sand from participation in pearl causation. We cannot agree with that attitude. There is no doubt that occasionally a particle of sand or other inorganic material does form the nucleus of a free pearl. We have ourselves found three such, out of hundreds of pearls examined, in the course of our investigation. But, as a rule, any such foreign inorganic matter introduced between the mantle and the shell gives rise only to a pearly or nacreous excrescence, or blister, attached to the shell. Artificial pearls of an inferior sort are, however, sometimes produced in this way ; and the practice in China of forming rows of nacreous beads, or images of a Joss, or of Buddha, on the inner surface of the fresh-water mussel *Dipsas plicatus*, LEACH, depends simply upon the fact that foreign bodies placed outside the mantle will be cemented to the shell by a layer of nacre. The so-called "secret-process" of LINNÆUS, often referred to in the literature of pearl-formation, has been shown,* from manuscripts now in the library of the Linnean Society of London, to consist merely in piercing the shell and inserting a small fragment of calcareous matter kept in position by a piece of fine silver wire. LINNÆUS, on the evidence of contemporary manuscripts, seems to have obtained by the process certain pearls which the Swedish crown-jeweller declared to be in every way as good as those produced naturally. Probably they were compared not with the most precious pearls from the pearl oysters of Eastern seas, but with those of the Swedish fresh-water mussels (*Unio margaritifera*).

In 1898 BOUTAN experimented in artificial pearl-formation at Roscoff, and succeeded in obtaining pearls from the marine Gastropod *Haliotis;* and no doubt they might be obtained artificially from other shell-fish also.

The importance of all this, from our present point of view, is merely to show that the grain-of-sand method is occasionally found operative in the causation of true pearls, and it is possible that some of those that appear to have no nuclei may have been deposited around very minute inorganic particles.

The view that the pearl is produced as a calculus, or pathological deposit, was originated by RÉAUMUR in 1717, followed by BOHADSCH in 1761, was supported by MECKEL and by PAGENSTECHER nearly a century later, and again revived by

* 'Proc. Linn. Soc.,' 117th session, p. 18, 1905.

Dr. George Harley in 1889. Giard has recently pointed out that a considerable resemblance between the pearl and an animal calculus is compatible with the parasitic theory. Calculi commonly form around a nucleus, and many parasites are known to have calcified cysts deposited over them. Some pearls, as we shall show below, not of the finest quality, are probably formed as calculus-like growths independently of vermean parasites. Even when the parasite is present as a nucleus and causes the initial stimulation, it must be remembered that the pearl is produced by the molluscan host, not by the parasite, and so has been justly compared by more than one writer to an animal gall.

There are two papers by Harley in the 'Proceedings of the Royal Society.' The first (vol. 43, p. 461) dealt with the chemical composition of pearls, and the second (vol. 45, p. 612) with the structural arrangement of the mineral matters, and there Harley states two views, the one that they are "diseased concretions" comparable with "other morbid calculi," and the second that they are "misplaced pieces of organised shell." He recognises various kinds of nuclei, organic and inorganic, but also admits that pearls may sometimes begin "by the mere aggregation and coalescence of mineral molecules." (See our 'Calcospherules,' p. 27, below).

Composition of Pearl and Nacre.

In the paper on the "Composition of the Pearl and of Nacre," G. Harley and H. S. Harley ('Roy. Soc. Proc.,' 1888, p. 461) give the following as their analysis of "pure white pearls" (British, Australian and Ceylonese):—

Carbonate of lime	91·72
Organic matter (animal)	5·94
Water	2·23
Loss	0·11.

They also, for comparison, quote from Watts' 'Dictionary of Chemistry'* the following analysis of mother-of-pearl:—

Carbonate of lime	66·00
Water	31·50
Organic matter	2·50,

and express their surprise at the large amount of water found.

This difference between these two substances, produced in the same animal in a similar manner, and supposed to be so closely related to one another, is so very great that we felt that it was desirable to have another analysis made—especially since it is not stated in Watts' Dictionary who made the analysis quoted, nor what shell was

* Vol. iii., p. 1057, 1882.

used. A quantity of nacre was therefore detached from Ceylon pearl-oyster shells which had been lying dry in a box at the ordinary temperature of the Museum for about four years, and was handed to Dr. HERBERT E. ROAF, of the Bio-chemistry Department of the University of Liverpool, who has kindly supplied us with the following analysis :—

Calcium carbonate	88·79
,, sulphate	4·93
Organic matter	2·32
Water	2·28
Loss (no magnesium, no phosphates, faint trace of iron)	1·68.

From this it appears that the composition of the nacre is much more like that of the pearl than HARLEY supposed, and in fact the proportions of mineral matter and of water present in the two cases are practically the same if the "carbonate of lime" in the older analysis may be regarded as expressing the total salts of calcium present. The only notable difference remaining is the larger amount of organic matter in the free pearl than in nacre. In both, the calcareous part is in the form of aragonite.

The abnormal pearls which are formed not of nacre but of prismatic layers (calcite) or of horny material may very possibly have a composition widely different from that of the true orient or "cyst" pearl.

PEARLS AND PARASITES.

It is commonly thought that the Italian naturalist, PH. DE FILIPPI, originated in 1854 the view that the nucleus of the pearl is really organic, being an encapsuled parasite. But GIARD has recently reminded us that RONDELETIUS propounded the same view in 1558, and that ages before that ANDROSTHENES, who had travelled in the East, is reported by ATHENÆUS to have compared the developing pearls in the oyster to the Cestode larvæ in "measly" pork. This, in the absence of microscopic examination, can scarcely be regarded as a scientific demonstration ; but it was at least a very happy guess, for one of the first facts that we were able to determine in connection with the Ceylon pearl oyster, in the spring of 1902, was that the orient pearl in the Gulf of Manaar is deposited around the young larva of a Cestode.

Coming to actual identifications of the organic nucleus in comparatively recent times, we find that FILIPPI'S pearl-parasite in *Anodonta cygnea* was the Trematode *Distomum duplicatum*, v. BAER ; ROBERT GARNER (in 1871) records "Distomes" from both fresh-water and marine mussels ; and GIARD attributes the origin of pearls in *Donax* and *Tellina* to a species of *Brachycœlium*—all these being cases of Trematoda. Other naturalists have since extended the discovery to other pearl-producing molluscs and to other worm parasites. To E. F. KELAART belongs the honour of having first connected the formation of pearls in the Ceylon oyster with

the presence of vermean parasites. He and the Swiss zoologist, A. HUMBERT, who was with him at a pearl fishery off Aripu in 1857, found various parasitic worms infesting the viscera and other parts of the pearl oyster, and they agreed that these worms played an important part in the formation of pearls. KELAART moreover, in 1859, made the remarkable suggestion, in the case of the Ceylon pearl oyster, that it might be possible to increase the quantity of pearls by infecting the oysters in other beds with the larvæ of the pearl-producing parasites. This is exactly the idea that has lately been revived by DUBOIS in France.

OBSERVATIONS ON MYTILUS PEARLS.

Turning now to European shell-fish, we find that our countryman, ROBERT GARNER, in 1863 and again in 1871* associated the production of pearls in our common English mussel (*Mytilus edulis*), as well as in Anodon, with the presence of Distomid parasites.

Professor GIARD, in 1897, and other French biologists since, have made similar observations in the case of *Donax* and other Lamellibranchs—GIARD describing† the Distomid worm which he found as a species of *Brachycœlium* which he has identified since with *Distomum constrictum*, MEHLIS. LÉON DIGUET, in 1899, described the pearl-sac which secretes concentric layers of the nacreous deposit around the remains of parasites. We now come to quite recent years, during which there has been great activity. Professor RAPHAEL DUBOIS, in 1901, ascribed the production of pearls in mussels on the French coast to the presence of the larva of *Distomum margaritarum*. The next year (1902) Dr. H. L. JAMESON‡ followed with a more detailed account of the relations between the pearls in *Mytilus edulis* and the Distomid larvæ which he identified as belonging to *Distomum* (*Brachycœlium*) *somateriæ*§—the same sub-genus as GIARD had found some years previously in other Lamellibranchs. JAMESON'S observations were made partly at Billiers (Morbihan), the same locality at which DUBOIS had also worked, and partly at the Lancashire Sea Fisheries Laboratory at Piel, in the Barrow Channel. DUBOIS published a further note‖ in January, 1903, in which he stated that JAMESON had come to Billiers after his departure and had confirmed the discovery made previously, first by GARNER and then by himself. But JAMESON had really done much more than that. He had shown that it is probable that the parasite causing the pearl formation in our

* 'British Association Report' for 1863, p. 114; and 'Journ. Linnean Soc., Zool.,' vol. xi., p. 426.

† 'Comptes Rendus Soc. Biol.,' November 13, 1897, p. 956.

‡ 'Proc. Zool. Soc. Lond.,' 1902, p. 140.

§ GIARD states ('Feuille des Jeunes Naturalistes,' January 1, 1904) that this species is the *Distomum constrictum* of MEHLIS, but there seems some reason to believe that JAMESON had more than one species under observation.

‖ 'Comptes Rendus Acad Sci.,' January 19, 1903.

common mussel (*Mytilus edulis**) is the larva of *Distomum somateriæ*, a Trematode worm, the adult of which† lives in the intestine of the eider duck and the scoter duck. He also stated that the larva inhabits Tapes or the cockle as a first host before getting into the mussel, and gave figures of the parasite in various conditions.

Two very important matters are, however, left in a somewhat unsatisfactory condition by JAMESON'S paper. The first of these is the mode of origin of the epithelial sac which encloses the larval parasite and which secretes from its cellular walls layer after layer of nacreous material so as to form a pearl. The presence of this sac was known before (VON HESSLING, 1858, and DIGUET, 1899), but no one had yet satisfactorily traced its origin. JAMESON several times compares it with the epithelium on the outer surface of the mantle, using such terms as "similar to" and "indistinguishable from," but he evidently considers that it has nothing to do with that epithelium, although it produces an identical pearly secretion. He describes the sac round the parasite as formed by the proliferation of a few cells which "are basally continuous with fibres of connective tissue." He also says of it, "This epithelium appears to arise quite independently of the outer epidermis." Now such a mode of origin as this is very unlikely, and from our own observations upon pearl-bearing mussels obtained from the same locality as JAMESON'S, we think there can be little or no doubt that the cells of the pearl sac are directly or indirectly, but at least genetically, connected with the exactly similiar cells on the outside of the mantle. It is very probable that the parasite in burrowing into the mantle carries in with it one or more epidermal cells which proliferate to form the sac. As the Distomid larvæ are found moving on the inner surface of the shell before coming to rest in the mantle, they must traverse the epidermis, and it is natural to suppose that in their migration they may push some epidermal cells in before them. Even in the absence of direct evidence of this, it will be admitted that it does not involve such a violent assumption as that the connective tissue in the centre of the mantle can produce an epithelial sac, the cells of which are indistinguishable both in structure and in function from the epidermis outside.

In giving a preliminary account of pearl-formation in the Ceylon pearl oyster to Section D of the British Association in September, 1903, we took up the position that the sacs enclosing the pearls were in all cases of ectodermal (epidermal) origin ;

* JAMESON also states that he had found a Trematode in a sac in an example of the Ceylon pearl oyster ('Nature,' January 22, 1903, p. 281).

† ODHNER, however, has shown that JAMESON'S larval stages and his sexually mature form cannot belong to the same species, and that both belong to the genus *Gymnophallus*. The adult, according to ODHNER ('Fauna Arctica,' iv., 2, p. 291, 1905) is *Gymnophallus somateriæ* (LEVINSEN), and the larval form which causes the pearl-formation in *Mytilus* belongs to *Gymnophallus bursicola*, ODHNER. In a recent paper, "Über die Entstehung der Perlen," Dr. M. LÜHE also refers JAMESON'S stages to different species of *Gymnophallus*, and considers it probable that the parasite that causes pearl-formation in the mussel is a distinct species which must then be called *Gymnophallus margaritarum* (DUBOIS).

and it was gratifying to find that Professor A. GIARD in a note* on the subject shortly afterwards took the same view and considered that in the case of JAMESON'S mussel pearls there is a "passive immigration" of the epithelial cells caused by the migrating parasite.

Just as this section of the report was going to press I received a letter from Dr. JAMESON (now on the staff of the Transvaal Technical Institute, Johannesburg) in which he says: "I had never any doubt that it is a true epidermis, but I never got so far as to determine actually by observation whether it arose, as I think you have suggested, by the Trematode carrying in with it a fragment or pocket of epidermis; or, as I suspected, by means of epidermal or sub-epidermal replacement cells (Ersatzzellen)." From this it may be gathered that Dr. JAMESON would now agree with GIARD and BOUTAN and ourselves that the epithelium of the pearl-sac must be derived directly or indirectly from the epidermis of the mantle.

The second point in JAMESON'S account which, from the evidence presented, is not quite satisfactorily settled is the supposed infection of the mussel with parasites by other mollusca—*Tapes decussatus* in France and *Cardium edule* (the cockle) in the Barrow Channel. So far as regards this case, JAMESON'S conclusion is based upon the experiment of placing some mussels which he supposed to be free from parasites in a tank with French *Tapes* which were infected, and examining the mussels from time to time until he found they contained the parasites (Cercaria). Now in such an experiment it is necessary to be quite sure of the material used, to deal with sufficiently large numbers, and to have control experiments. JAMESON may have taken these precautions, but it does not appear from his paper. He says of the material: "These mussels, of which I examined a number, were practically without parasites. About one in every five of the largest examples contained a Cercaria, one had two Cercariæ, and one contained a small pearl." This can scarcely be described as free from parasites. He used 70 mussels, and if we take his own figures, one in five, as accurate, then about 14 of these specimens were infected at the beginning of the experiment. We find from his records that he only examined 13 of these mussels (2 after 11 days, 6 after 2 months, and 5 after $6\frac{1}{2}$ months), and found 12 of them infected. But it is obvious that that number may have been infected from the beginning, or may have become infected at any time from neighbouring mussels. The theory of transference of the parasite from one mollusc (such as cockle) to another (the mussel) may be true, but it is not proved by those experiments. It was not shown that the mussels were free from parasites at the start, the numbers in the recorded experiments are too small to yield definite conclusions, and the observations should clearly be repeated, using hundreds of cockles and of mussels with well-devised control experiments. In order to show the necessity for large numbers in this kind of work, it may be added that, Mr. ANDREW SCOTT having informed us of Dr. JAMESON'S observations at Piel, we had some samples of these same mussels and cockles sent to the Liverpool Laboratory,

* 'Comptes Rendus Soc. Biol. Paris,' December 19, 1903, lv., p. 1618.

where, with the assistance of Mr. WALTER TATTERSALL, B.Sc., and Mr. J. PEARSON, B.Sc. (in October, 1902), an independent examination of them was made, with results that do not altogether agree with Dr. JAMESON'S.

We may distinguish between four kinds of mussels examined by both of us, and described by JAMESON as follows :—

(A) From the beds opposite the Piel Hatchery—" where every specimen is abundantly infected . . . . and almost every specimen contains pearls."
(B) From the piles of the old pier at Piel—" practically without parasites."
(C) From Roosebeck Scar, outside Barrow Channel—" not infected."
(D) Roosebeck Scar mussels transplanted to foreshore at Piel two years ago—" all were infested " . . . . " each contained several small pearls."

Of (A) we examined a sample of 25 mussels which contained in all 151 pearls and 11 parasites, but 4 of the specimens had neither pearls nor parasites and no less than 18 out of 25 had no parasites. We cannot therefore agree that " every specimen is abundantly infected."

Of (B) we examined also 25 mussels, which showed in all 21 pearls and 22 parasites, 7 had neither pearls nor parasites, and 13 had no parasites. These, then, showed far fewer pearls than (A), but twice as many parasites, and fewer of them were free from infection. They can scarcely be called " practically without parasites."

Of (C) we examined 28 mussels, which contained 73 pearls and 37 parasites, 4 had neither pearls nor parasites and only 9 (out of 28) had no parasites. These, then, are evidently just as much infected as the mussels on the Piel foreshore (A).

Of (D) we examined 24 mussels, and they contained 65 pearls and 26 parasites, 3 had neither pearls nor parasites and 12 out of 24 had no parasites. So in place of these transplanted " Roosebecks " having become more infected on the Piel shore, they on the whole showed rather less infection than the mussels taken direct from the parent bed.

Finally, we examined a sample of 25 cockles from Piel, and found in them 8 pearls, but no parasites at all of the right kind. This does not support the view that the cockle contains the earlier stage of the parasite and passes it on to the mussel.

At the end of October, 1902, Mr. ANDREW SCOTT, A.L.S., and Mr. JAMES JOHNSTONE, B.Sc., examined some further samples at Piel with the following results :—

(A) Examined 61, got 390 pearls and 191 parasites.
(B) ,, 103, ,, 100 ,, 61 ,, *
(D) ,, 53, ,, 161 ,, 66 ,,
(Roosebeck Scar mussels could not be got at the time.)

* Mr. JOHNSTONE, however, informed me that before he made this examination a gale had washed away some of the piles of the old pier, and that, consequently, his sample of (B) was obtained from rather a lower level than JAMESON'S and so may have contained more parasites.

The most noteworthy difference between these results and those given above are in the case of the parasites in (A), where Mr. SCOTT found about 7 times as many as we did. The sample of (B) in this case also, it will be noticed, is by no means free from infection. Since that time Mr. SCOTT has examined a few more samples from these same beds with slightly different results, and also a number of batches of mussels from other parts of the coast of the Irish Sea. As these may be interesting for comparison with other localities and other molluscs, we give Mr. SCOTT's notes, with which he has kindly supplied us, in summarised form, as follows :—

Beds on the estuary of the Wyre :—						
"Wardleys"	72	mussels had	30	pearls and	3	parasites.
"Hambleton"	11	,,	1	pearl ,,	0	,,
"Skear"	12	,,	1	,, ,,	0	,,
"Knott End"	10	,,	0	pearls ,,	3	,,
"Fleetwood Lighthouse" .	13	,,	23	,, ,,	6	,,
On the Lune :—						
"Crook Skear"	10	,,	2	,, ,,	1	parasite.
"Abbey Skear"	10	,,	0	,, ,,	0	parasites.
On the Ribble :—						
"St. Anne's"	9	,,	2	,, ,,	0	,,
"North Training Wall" .	27	,,	1	pearl ,,	0	,,
At Morecambe :—						
"Ringhole"	42	,,	27	pearls ,,	27	,,
"Knott End"	32	,,	0	,, ,,	5	,,
"Bailing Knott"	34	,,	3	,, ,,	12	,,
"Reap Skear"	5	,,	0	,, ,,	0	,,
Cheshire :—						
"Wallasey"	68	,,	0	,, ,,	0	,,
North Wales :—						
"Conway"	12	,,	33	,, ,,	8	,,
"Ogwen River"	15	,,	77	,, ,,	14	,,
"Llanfairfechan"	20	,,	18	,, ,,	1	parasite.
"Carnarvon"	18	,,	9	,, ,,	8	parasites.
"Aberdovey"	21	,,	2	,, ,,	0	,,
"Barmouth"	26	,,	6	,, ,,	4	,,
Barrow Channel :—						
"Roa Island"	53	,,	231	,, ,,	77	,,
	520		466		244	

The totals show nearly as many pearls as mussels, and nearly twice as many pearls* as parasites, but that must not be considered as a conclusion that can be generally applied. The last item on the list shows how much more abundant the pearls and parasites may be in one locality than in others.† In fact, we do not wish to attach much weight to any of these figures given above. The point we desire to make is rather that in working with these comparatively small samples each fresh examination gives a somewhat different result, and that, consequently, it is necessary that some one living on the spot, with abundance of material at hand and with tanks for experiments under constant observation, should make a comprehensive investigation of some hundreds or thousands of each kind of mussel and cockle in order to clear up the distribution of pearls and parasites, and settle this question of infection.

It must not be supposed that we are disputing Dr. LYSTER JAMESON'S theory of pearl-formation. We recognise the excellence of his work and appreciate the energy he displayed in prosecuting the research, both at Billiers and at Piel. His paper marks a distinct advance in our knowledge of the subject. But there remain the two points on which it seems to us the evidence in JAMESON'S paper is not completely satisfying. These are (1) the origin of the epithelial sac that secretes the pearl, and (2) the infection of the mussel from a previous molluscan host, the *Tapes* or the cockle. There may be such a host, but JAMESON'S observations and our own later ones leave the matter still doubtful.

Finally we desire to emphasise the point that JAMESON'S observations and conclusions refer to pearl-formation in the common marine mussel of North-west Europe, *Mytilus edulis*, and cannot, without further evidence, be extended to other pearl-bearing molluscs. It is becoming clear that several parasitic worms and several distinct processes are at work in bringing about the production of pearls in shell-fish.

ARTIFICIAL INFECTION.

To continue our historical survey, Professor M'INTOSH‡ has described the examination of 700 mussels from near St. Andrews, where he found that 300 in all, or nearly 43 per cent., were pearl-bearers—a small proportion, however, com-

* In comparing these statistics with those of the Ceylon pearl oyster, one is struck by the wholly different ratio borne by pearls to parasites in the two cases. In the mussels, pearls are far more numerous than the living parasites. In our Ceylon oyster, parasites may be exceedingly abundant; while pearls (cyst-pearls) are relatively very rare, probably not more than one to a hundred parasites.

† Mussels that grow rapidly and regularly have few pearls. It is the old "blue-nebs" of uncertain age and battered appearance that have the most pearls. We may add that the same general principle holds good in the case of the Ceylon pearl oyster. The most prolific pearl-bearers are those of stunted appearance and somewhat rounded form the "Koddapakku" or Areca-nut oysters, as the divers call them.

‡ 'Ann. Mag. Nat. Hist.,' June, 1903, p. 549. W. NICOLL has a recent note ('Ann. and Mag.,' January, 1906) on Trematode parasites in the cockle and mussel at St. Andrews. He finds the adult in the oyster-catcher, but it is evidently not the form described by JAMESON, since NICOLL refers to it as probably a new species of *Echinostomum*.

pared with our results from Piel. He associates the occurrence of pearl-bearing mussels in St. Andrews Bay with the presence of large numbers of parasites in the wild ducks that feed upon these mussels; and suggests that possibly other birds, such as the oyster-catcher, may be found to harbour the same parasites.

Professor R. Dubois, whose former observations had been made in Morbihan, has since turned his attention to the Mediterranean coast. He found that the southern French mussel (*Mytilus gallo-provincialis*) forms pearls caused by another Distomid, distinct from that of Brittany. He then worked at the acclimatisation of a true oriental pearl oyster ("pintadine") in French waters and the artificial production of pearls.* He brought the pearl oysters from the Gulf of Gabes, in South Tunis, to the marine laboratory at Sfax, and caused them to multiply and increase in size. The pearls produced in Tunis are small and very rare—it is necessary to open 1,200 to 1,500 oysters to find one pearl; but Dubois tells us† that by placing them on ground where *Mytilus gallo-provincialis* becomes infested with pearls and parasites, he very easily provoked the production of fine pearls in the "pintadine" to such an extent that three successive individuals opened contained each two little pearls. This, if corroborated, is a remarkable circumstance from several points of view. First, it will, if it proves a success, be a striking verification of what Kelaart in Ceylon, fifty years ago, declared might be done. Secondly, if the "pintadine" in question is really the same species as the Ceylon pearl oyster (Giard considers that it is not), it is curious that a Distomid parasite should prove to be so efficacious in setting up pearl-formation, since we have found that in the Gulf of Manaar the pearl-parasite is a Cestode larva. Thirdly, it is remarkable that the parasite of the *Mytilus* should transfer itself so readily to a new host belonging to a distinct family.

It is this last paper by Dubois that has given rise to various more or less exaggerated or even erroneous statements in the public Press, such as that the pearl-oyster must be infected with a microscopic germ in order to render it pearl-producing; or even that inoculation with a serum causes the oyster to produce artificial pearls. The parasite that causes the irritation is, as has been known for many years, not a "germ," and still less a "serum," but a worm which is visible to the eye—a worm which in *Mytilus* seems to be usually a Trematode, and in the Ceylon pearl oyster (*Margaritifera vulgaris*), according to our observations, is certainly a Cestode.

According to an interesting note by Professor Giard,‡ the discovery of Cestode larvæ as nuclei of pearls, which we had made upon the Ceylon pearl oyster in 1902, was shortly afterwards corroborated by Dr. L. G. Seurat, working independently in his laboratory at Rikitea in the Island of Mangareva (Gambier Archipelago). The oyster on which Seurat worked was *Margaritifera margaritifera*, var. *cumingi*,

* Comba had, however, in 1899, introduced the same mollusc on the South Coast of Italy, and experimented there in artificial pearl-formation.

† 'Comptes Rendus Acad. Sci.,' October 19, 1903, p. 611.

‡ 'Comptes Rendus Soc. Biol. Paris,' November 6, 1903, lv., p. 1222.

REEVE, and the Cestode parasite found, is, according to GIARD, an *Acrobothrium* (= *Cyathocephalus*) or some allied form. Some of our Ceylon pearl-oyster parasites very closely resemble the figures given by GIARD, and possibly may also belong to the genus *Cyathocephalus*, although most of them are certainly Tetrarhynchids.

GIARD, in a further note in the same Journal (p. 1225), discusses the statements that have been made in regard to "margarose artificielle," and evidently considers that DUBOIS' claim to have established the artificial production of pearls is not yet justified by the facts. About the same time, M. L. BOUTAN* wrote showing that "fine pearls" do not really differ from "nacre-pearls," since both are secreted from open or closed epithelial sacs derived from the epidermis; and GIARD very properly replied, a few days later,† that this fact is quite in accord with general principles, and was previously known. M. BOUTAN then published a more detailed account‡ giving figures illustrating his point that in all cases the pearl-sac is formed by an invagination of the surface of the mantle, and that it is of ectodermal origin, not mesodermal as he supposed JAMESON to have indicated. Finally, in a letter (January 20, 1904) to one of us, he states that he is on the point of departure for the East in order to investigate the matter further. The results have not yet appeared.

CEYLON PEARLS AND PARASITES.

Turning now to the investigations on the Ceylon pearl oyster in the Gulf of Manaar, let us first recall the work of our predecessor, Dr. E. F. KELAART, in the same field and on the same animal nearly half a century ago. KELAART, in 1857, in his "Introductory Report on the Natural History of the Pearl Oyster of Ceylon," after describing the secretion of nacre by the mantle, said:—"It will be thus clearly understood, that when a grain of sand or the larva of an insect is introduced between the mantle and shell, it will become covered over with the pearly secretion; which, always going on, is augmented at the part where the foreign matter lies. This phenomenon I have detected with the aid of the microscope, in its very earliest stage." The probability is that by "larva of an insect" in this passage KELAART meant such an organism as the Cestode larva which we now find is the determining cause of such pearl-formation.

In another passage, in his "Report on the Pearl Banks of Arripo for Season 1858," he says:—"The presence of a worm (a species of *Filaria*) found in the oysters has, I am positive, much to do with the formation of pearls. I would rather reserve this part of my investigation for longer experience. But this much I can say at present, with perfect safety: that whenever I found good pearls in a batch of oysters, I found this worm and its eggs in large numbers in the liver, ovary, mantle, and other parts

* 'Comptes Rendus Acad. Sci.,' December 14, 1903, p. 1073.

† 'Comptes Rendus Soc. Biol. Paris,' December 19, 1903, p. 1618.

‡ "Les Perles Fines: leur Origine réelle," 'Arch. Zool. Expér.,' sér. 4, t. ii., p. 47, 1904.

of the oyster." This "Filaria" may possibly be either the *Ascaris* or the *Cheiracanthus* which we have found, and which are described as new species by SHIPLEY and HORNELL; or it may possibly be the elongated, later stage of the *Tetrarhynchus* larva which also occurs.

Finally, at the end of KELAART's last Report (1859) occurs the remarkable passage where, in speaking of the corroborative observations of Mons. A. HUMBERT, he said :—"We both agree that these worms play an important part in the formation of pearls; and it may yet be found possible to infect oysters in other beds with these worms, and thus increase the quantity of these gems." As we stated in the Introduction to this work (Part I., p. 7, 1903), "Dr. KELAART'S short reports show that he was tackling the problems in a scientific manner, and his researches were incomplete at the time of his sudden death."* We may take these observations as our point of departure. THURSTON, in 1894, however, confirmed KELAART, finding in the tissues and also in the alimentary canal of the oyster "larvæ of some platyhelminthian (flat worm)"; but he was able to add little beyond figuring ("Madras Museum Bulletin," I., Plate ii., fig. 1) a section showing two of the parasites encysted between the alimentary canal and the gonads. Here the matter practically rested so far as actual investigation of the Ceylon pearl oyster was concerned, until we found the Cestode larvæ in association with pearls in the tissues during our cruises in the "Lady Havelock" in the Gulf of Manaar, in February and March, 1902. It was about March 6th (see "Narrative," p. 70, in Part I.), when cutting up oysters from the western part of the Cheval Paar, that we first became convinced that the opaque white globular larvæ we were finding encysted in the liver belonged to Cestode worms. Subsequent work showed us that some of them at least were referable to the genus *Tetrarhynchus*, and the various stages that we were able to find up to the spring of 1904 were described by SHIPLEY and HORNELL in Part II., p. 79.

Since then large numbers of pearl oysters from various paars in the Gulf of Manaar have been examined by us in the field and in the laboratory, and although many small pearls and many parasites have been found, it is apparently very difficult indeed to hit upon a stage showing the commencement of the pearl-formation, or any evidence bearing on the entrance of the parasite into the mollusc.

The youngest stages in the life-history of *Tetrarhynchus* are still unknown, and it is still uncertain whether the free-swimming larvæ found on Muttuvaratu Paar really belong to this life-history. They have calcareous corpuscles and an indication of an invaginated head, and are almost certainly young Cestodes. We reproduce here (fig. 1) four of the figures of this presumed youngest stage, given by SHIPLEY and HORNELL, and are unable to add anything to their statement (*loc. cit.*, p. 86) :—"On the whole we think it probable that this larva is the first stage in the life-history of the pearl-forming organism," &c.

* When in medical attendance on General LOCKYER. Both the General and the Doctor died in the Red Sea, in 1859.

Many of the pearl oysters which we examined in the Gulf of Manaar in February and March, 1902, and also those we have examined since, both in Liverpool and at Ceylon, show numerous encysted parasites in various parts of the body. We have

Fig. 1. Free-swimming larvæ caught in the tow-net on Muttuvaratu Paar.

found these cysts on the branchiæ, in the mantle, in the liver and gonads, and elsewhere amongst the viscera. Fig. 2, giving a transverse section (A) and a lateral view (B) of a pearl oyster, shows a number of pearls and a few encysted parasites in the positions where we most commonly find them.

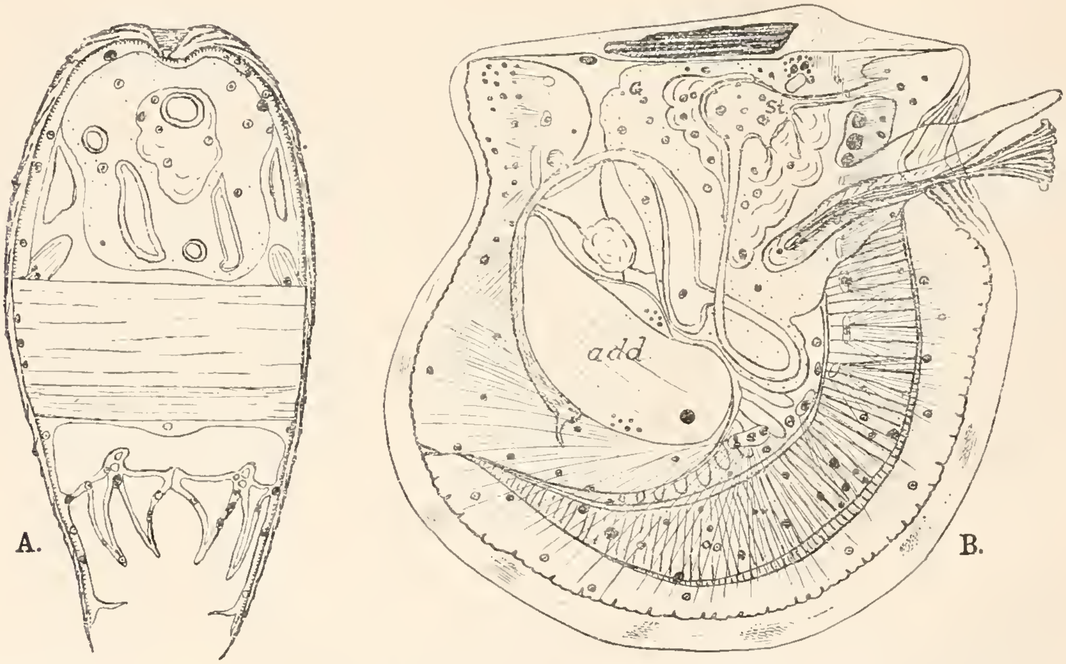


Fig. 2. **A**, transverse section of *Margaritifera vulgaris*, and **B**, dissection from the right side, to show the usual positions occupied by pearls and parasites.

These cysts, though small, are usually visible to the eye, and measure from 0·13 millim. to 1·3 millims. in diameter. The contained parasite is not always in the same stage of development, but is always, so far as our observations go, a young Cestode worm. It is possible, however, that more than one species of Cestode is

represented—one is certainly a species of *Tetrarhynchus* (*Rhynchobothrius*), and another is probably the same genus or may possibly belong to *Cyathocephalus*, KESSLER (= *Acrobothrium*, OLSSON), characterised by the unarmed head and the terminal circular bothrium.

SEURAT, writing in 1906,* states that in the case of the pearl oysters (*Margaritifera margaritifera*, var. *cumingi*, REEVE) of the Gambier Archipelago the numerous encysted parasites scattered through various parts of the body—branchiæ, mantle, heart, liver, &c.—are the scolices of Cestodes "appartenant aux genres *Cyathophyllus* [*Cyathocephalus*†] ou *Acrobothrium*."

In a letter received on February 28th, M. SEURAT gives as his latest opinion "L'adulte du Cestode qui produit les perles à Mangareva vit dans la raie-aigle; je me propose de l'appeler *Aphanobothrium*, n.g., *margaritiferæ*, genre voisin des *Cyathocephalus*, KESSLER." Finally, in a further letter (March 8th), he says:—"Je crois pouvoir ranger le Cestode margaritifera dans le genre *Tylocephalum*, LINTON, et ne pas avoir à créer de nouveau genre. Ce sera donc le *Tylocephalum margaritiferæ*. Hab. scolex—*Margaritifera cumingi*, REEVE. Hab. adulte—Intestin spiral de *Ætobatis narinari*, EUPHR."‡

We agree at least with SEURAT that the parasites are Cestodes, and that is clearly the first point to establish.

In order to be able to co-relate our work with that of Dr. JAMESON and make a comparison between the Ceylon specimens and those from European seas where the parasite is a Trematode, we obtained material from the pearl-bearing mussels (*Mytilus edulis*) at Piel,§ on the Lancashire coast, the same locality where Dr. JAMESON worked. Figs. 1 to 12 on Plate I. show the condition of affairs in this material; and the chief points of contrast with the Ceylon pearls are:—

(1) The distinctness of the pearl-sac (figs. 8, 10, 11).
(2) The large size of the nucleus in the pearl (where a nucleus is present) and its characters, which are quite different from those of the encysted parasites in the Ceylon pearl oyster.

We agree entirely with JAMESON, of course, that the organism in the *Mytilus* pearls is a Distomid, and the marked difference that we find in our own preparations of the two cases (*Mytilus* and *Margaritifera*) confirms us in our belief that the Ceylon parasite cannot be a Trematode.

* "La Nacre et les Perles en Océanie Française," par M. L. G. SEURAT, Chargé de mission à Tahiti, in 'Compte Rendu des Trav. Première réunion internat. d'Agronomie Coloniale': ALCAN, Paris, p. 308.

† SEURAT writes "*Cyathophyllus*," but surely that must be intended for *Cyathocephalus*.

‡ Since published in 'C.R. Acad. des Sci.,' 26 Mars, 1906, p. 801.

§ We are indebted to our friend Mr. ANDREW SCOTT, A.L.S., Resident Naturalist at the Piel Marine Laboratory, for the help he has kindly given us in this matter; and to Mr. T. SOUTHWELL, in the Liverpool Laboratory, for assistance in the preparation of many specimens.

Before leaving the *Mytilus* material, we may add two further points of interest. The first is that some pearls have no trace of a nucleus. Plate I., fig. 5, shows a case where a careful search through all the sections (serial) showed no internal cavity and no imbedded foreign structures We have similar cases also in our Ceylon material. The second point is that in some places the pearl sac shows a mass of enlarged and proliferating epithelial cells which are generally adherent to the pearl at points where there is a depression and a marked irregularity in the deposition of the layers (Plate I., figs. 10 and 11). Some of the *Mytilus* pearls are exceedingly irregular in form, projections being given off which appear like separate pearls in some of the sections (fig. 11). In addition to such cases, there are sometimes two or more pearls in the same sac (fig. 2), and in figs. 6 and 7 we find a pearl and a parasite enclosed together by the one layer of epithelium. In some places small blood sinuses adjoin the pearl-sac for portions of its extent, but these are not larger than those seen elsewhere in the mantle of *Mytilus*. We do not find that the pearl-sac is surrounded by a blood sinus, as BOUTAN states is the case.

ENCYSTED CESTODES.

The smallest and simplest cysts we have seen in the Ceylon pearl oyster are in the mantle (Plate II., fig. 1). They have no pearl and no pearl-secreting epithelial sac, and the connective-tissue cyst contains an embryo which shows only an outer wall and some irregularly scattered internal cells. It is presumably an onchosphere or pro-scolex stage in which the hooks have been lost and invagination to form the scolex has not yet taken place.

Similar early stages are found also in the gills, either in the principal gill filaments (see Plate II., fig. 3), or, more usually, alongside the great blood-vessels in the axis of the gills where they adjoin the body.

The majority of the cysts, however, contain later stages (text-fig. 3) where more or less invagination to produce the scolex has taken place. These measure from 0·07 millim. to 0·16 millim. in longest diameter, most of them are about 0·14 millim. A number may be present in the same host; we have frequently seen two close together in the same section, under the microscope. Figs. 17 to 22 on Plate II. show several of these stages, from the liver, the gonads, and the mantle. One end of the globular or ovate parasite forms a cup-like invagination with a central boss or papilla rising from the bottom of the cup. In some cases the margin of the cup is turned in so as almost to close the aperture. Round the outside of the invagination there may be more or less of a projecting pad in the form of a collar or annular thickening. This form (seen typically in Plate II., fig. 17) agrees very closely with the figures given by SEURAT for the pearl-causing Cestode parasite of the Gambier Islands,* and with the figures given by SHIPLEY and HORNELL of the nuclei of pearls in Part II. of this Report

* See GIARD, "L'Origine Parasitaire des Perles," 'Comptes Rendus Soc. Biol.,' lv., p. 1222.

(p. 79, 1904). Although most of those which we have examined are not surrounded by any pearl, there can be no reasonable doubt that these are the parasites that form the nuclei of the orient pearls. When we compare SHIPLEY and HORNELL'S figures

Fig. 3. Young larval Cestode (*Tetrarhynchus*, sp.) encysted in connective tissue of pearl oyster.

(Part II., Parasites, Plate I., figs. 4 to 6 and 13) with SEURAT'S figures (GIARD, *loc. cit.*, figs. 1, 2 and 3) and our present figures (Plate II., figs. 17 to 22 and Plate III., figs. 1 to 8) there can be little or no doubt that these all represent similar stages in the same kind of organism. We do not mean that our larvæ necessarily belong to the same species as SEURAT'S. In fact, differences in size and details of structure convince us that they are not identical, but the resemblance is sufficiently close to indicate that they all belong to allied organisms.

Moreover, it is clear that these are all larval Cestodes in the blastocyst condition containing young scolices. It was the possession of calcareous corpuscles noticed in the fresh condition in 1902 in the Gulf of Manaar that caused us first to identify these larvæ as Cestodes. We now enumerate as Cestode characters :—

1. The invagination to form the head of the adult worm ;
2. The hooks upon portions of the invaginated surface ;
3. The calcareous corpuscles in the walls of the vesicle ;
4. The division of the (? muscular) tissue on the floor of the invagination into several masses (probably four, as either two or three can usually be seen in different views).

The invagination (Plate II., figs. 17, 20) agrees very closely with the "figures idéales" of early stages of the genus *Tetrarhynchus* given by P. J. VAN BENEDEN ("Vers Cestoïdes," pl. xxiii.), and with the sections of the larvæ of *Rhynchobothrius adenoplusius*. PINT., from *Lophius*, showing receptaculum and developing scolex, published in the third part of his 'Studien über Tetrarhynchen' (Taf. ii.,

fig. 11), by PINTNER, in 1903, and is quite consistent with the section of a Cysticercus of *Tetrarhynchus* given by MONIEZ in his 'Essai Monographique sur les Cysticerques,' at plate iii., fig. 1, and with PINTNER'S figure of *Tetrarhynchus smaridum* ('Sitzb. Akad. Wiss., Wien.,' Jahrg. 1893, Abth. I.).

The hooks (Plate III, figs. 2 and 9) are similar to those shown by various authors as belonging to different larval Cestodes. The spines upon the projecting annular pad or collar are, for example, rather like those of *Tænia* (*Devainea*) *frontina*, DUJARDIN; and PINTNER shows a very similar arrangement to what we figure, in his 'Studien über Tetrarhynchen,' III., Taf. i., fig. 6.

The calcareous corpuscles are not seen so well in the preserved specimens from which the sections have been made in Liverpool as they were in the fresh material we examined in Ceylon, but there can be little doubt that it is the remains of these bodies that we show along with the loose network of connective tissue in the vesicle behind the invagination in figs. 6, 7 and 8 on Plate III.

The division of the more opaque (? muscular) tissue in the scolex at the bottom of the cup cannot be seen distinctly in all specimens, but the appearance shown in Plate II., figs. 19 and 20, can scarcely be interpreted otherwise than as the beginning of the segregation to form four discs (or bothridia) with their proboscides.

The possession of all these characters together, in our opinion, definitely stamps the organisms as larval Cestodes. It is no easy matter, however, to refer these larvæ to their proper genus. We find later stages in the tissues of the pearl oyster which clearly belong to *Tetrarhynchus*, in a wide sense, but it is difficult to find conclusive evidence that these younger larvæ belong to the same organism as the later forms with four proboscides. GIARD is of opinion that SEURAT'S similar figures represent a member of the group Monobothria in the order Pseudophyllidea. SEURAT gives as his later opinion, as we have shown above, that they belong to a new species of LINTON'S genus *Tylocephalum*. In either case the terminal invagination would represent a sucker with a papilla on its floor. We are inclined to regard it rather as the opening in a hood or depression formed by the sinking of the scolex into the front of its vesicle. The changes of shape which we observed in this larva in the living state, the protrusion and retraction of the papilla-like part which we regard as the anterior end of the scolex, agree with this interpretation. Consequently, we are of opinion that this larval Cestode is not one of the Monobothria—that it belongs to neither the Pseudophyllidea nor the Tetraphyllidea, but is a young Tetrarhynchid belonging to the Trypanorhyncha, and we give here (fig. 4) a series of diagrams in order to show the positions that we suppose our stages to occupy in the development of such a form.

In regard to the life-history of the pearl-inducing parasite, we have little to add to what has already been published in the preceding parts of this Report. In the Introduction (Part I., p. 12) an outline of the history was sketched which still holds true in the main. SHIPLEY and HORNELL in Part II. (p. 77) described and figured

various stages of the Cestode larvæ both from the centre of decalcified pearls and also free in the tissues of the pearl oyster, but left it an open question whether the sub-globular younger larvæ belong to the same life-history as the elongated older forms

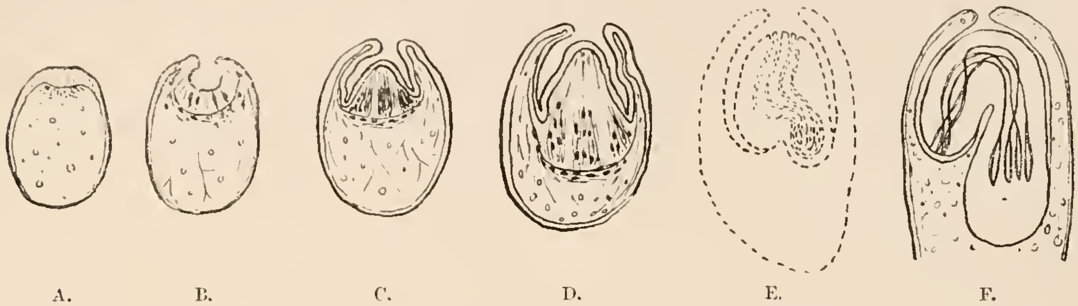


Fig. 4. Series illustrating the connection between the Cestode larvæ found in the pearl oyster. A, B, C, and D represent stages that commonly occur, E is the hypothetical connecting link, and F is a young *Tetrarhynchus*, copied from fig. 31, of Plate II., in the "Report on the Parasites of the Pearl Oyster" (Part II.). Since this figure was made, a still younger *Tetrarhynchus*, very slightly more advanced than is shown in E here, has been found in the liver of the pearl oyster (see text, p. 22, and Plate III., fig. 10).

which are young Tetrarhynchids. If our arrangement ot the stages observed in the tissues of the pearl oyster is correct, and if all these larvæ belong to the same species, then the interpretation we have given above brings us to the conclusion that the larger of our two globular larvæ belongs to the worm which Shipley and Hornell described as *Tetrarhynchus unionifactor* in 1904. Figs. 1 to 8 on Plate III. show most of the common stages we have found, and in regard to which there can scarcely be any doubt (1) that they all belong to the same life-history, and (2) that they are young Tetrarhynchids leading on to the stages shown in figs. 10 and 11.

If we distinguish the genus *Rhynchobothrius* from *Tetrarhynchus* by the possession of only two bothridia, then the correct name of the species becomes *Rhynchobothrius unionifactor* (Shipley and Hornell). The adult condition of this species is found in the large ray *Rhinoptera javanica*, M. and H. (see this vol., p. 65). In addition to these larger larvæ there is, however, a smaller form of globular larva (Plate II., fig. 19, &c.) which we meet with in the tissues of the pearl oyster, and which probably belongs to a distinct species of Cestode. The two forms of larvæ are seen side by side in fig. 17 on Plate II., and, as shown there, the larger (B) is about six times the diameter of the other (A). The two are, however, closely related forms and in similar stages. In both there is the same anterior invagination with the central papilla—various stages in the formation of which are shown in figs. 20, 21, 22 on Plate II. and figs. 1, 2, 6 and 8 on Plate III. There are the same cuticular spines round the margin of the invagination in both, and the same histological structure in the body wall of the vesicle and the future scolex. In size, Seurat's larvæ approach more nearly to our smaller form; but differ from both in proportions and details of structure.

Although we have examined sections of several hundred of these parasites from

various parts of the pearl oyster, we have been unable to find any stage intermediate between that shown in figs. 6 and 8, on Plate III., and the young *Tetrarhynchus* with four proboscides. It is probably therefore a rare occurence for the larva to advance further in its development in this molluscan host; but that it does occasionally happen is shown by our finding a few young Tetrarhynchids in cysts on the wall of the pearl oyster's intestine (see Plate III., fig. 11, for a section of this stage, and fig. 16 on Plate II. for the general appearance of what is probably the same species). We have found, in all, about six such Tetrarhynchids in company with over 200 of the globular parasites. If the parasite normally does not go beyond the globular stage in the body of the pearl oyster, but only occasionally advances a stage further and acquires the four proboscides, and then again remains quiescent in a cyst, it follows that the transition form which we have looked for in vain may be passed over very rapidly. In that case we should find the greater number of the parasites in the younger globular stage, a very few in the more advanced Tetrarhynchid condition, and practically none in an intermediate state.

Since the above was printed, and the diagrams shown in text-fig. 4 (p. 21) were drawn, we have found, encysted in the liver of the pearl oyster, a very young Tetrarhynchid larva which possesses the characteristic four proboscides, but has not yet become elongated. It is of ovate form (Plate III., fig. 10) and measures 0·53 millim. in length. It shows at the anterior end the lateral projections bounding the central depression just as in earlier stages (see fig. 6), but the central papilla is traversed by several openings which are clearly the tubular proboscides (fig. 10). In fact it agrees so well in all other respects except the proboscides with the larger form of globular larva that we can scarcely fail to recognise it as the later stage of the same animal—*Rhynchobothrius unionifactor* (SHIPLEY and HORNELL).

SHIPLEY and HORNELL have described (this vol., p. 43, *et seq.*) several other species of *Tetrarhynchus* from Ceylon, but none of them from the pearl oyster; so we are as yet unable to refer to its species the smaller globular larvæ which we find commonly encysted, and which may occasionally form the nuclei of pearls.

Both our larval Tetrarhynchids we believe to be pearl-inducing parasites in the Ceylon pearl oyster. The figures on Plate II. show for the most part the appearances presented by the smaller globular parasite in our specimens. Though small, they are visible to the eye (figs. 1 and 2). Fig. 17 shows the relation in size between the two kinds of larvæ—the larger (0·9 millim. in length) being about six times the size of the smaller (0·14 millim. in length). SEURAT'S larvæ are 0·25 millim.

We give on Plate II. (figs. 3 to 16) some of the drawings made by one of us (J. H.) in Ceylon, and which were used in SHIPLEY and HORNELL's article upon the parasites of the pearl oyster (this work, Part II, 1904). They show mode of occurrence in the tissues (figs. 1, 2, 3, 17, 18, 19), relation to pearls (figs. 4, 5, 6, 7), stages in the structure of the larva (figs. 8, 9, 10, 17, 20, 21, 22), differences in the amount of the connective-tissue cyst (figs. 17, 18, 19, 21, 22), and finally some later stages of

Tetrarhynchids which we have met with either in the pearl oyster or in fishes which we know to feed upon that mollusc (figs. 11, 12, 13, 14, 15, and 16).

It is quite evident from the examination of a large series of sections, such as we have worked through, that the majority of these encysted parasites do not become encased in pearls. Probably none of those in thick connective-tissue cysts are destined to form nuclei. They are awaiting their legitimate further development in the next host, after their sheltering mollusc has been devoured by a fish. In such cysts and around such parasites we find no epithelial sac, and as a consequence there can be no pearl. Whether or not it is the case that only dead parasites supply the stimulus necessary to induce pearl-formation, and whether, as GIARD has suggested, the parasites may be infested and killed by a species of *Glugea*, so that that Sporozoon comes to be eventually responsible for the pearl, we are not prepared to say—we have found no fresh evidence in the Ceylon material bearing upon that point. It seems clear to us, however, that the epithelium is always associated with pearl-formation, and that in the absence of the epithelium only a thick-walled connective-tissue cyst is produced. If we adopt the view (see below) that this epithelium is genetically related to the ectoderm, then a possible explanation of the difference in behaviour in the encysted condition would be that those larvæ that carried in ectodermal cells became covered (when dead or while still alive) by a pearl sac and embedded in a pearl, while those that were free from ectoderm become surrounded by the connective-tissue cyst.

The larger globular larva (*Tetrarhynchus unionifactor*) is illustrated in Plate III. Figs. 5 and 6 show common stages; fig. 8 is more highly magnified, giving histological details, and the spines at the anterior end are shown enlarged in fig. 9. The sections represented by figs. 3 and 4 are probably oblique. Fig. 11 shows a section of a young *Tetrarhynchus*, such as we find in the wall of the intestine and occasionally elsewhere in the tissues of the pearl oyster; and after the finding of the intermediate form shown in fig. 10, it can scarcely be doubted that these Tetrarhynchids are a later stage of the pearl-inducing globular larvæ.

In our first account of these parasites we suggested that the next stage after that found in the pearl oyster, occurred in a species of *Balistes*, which we showed was sometimes found feeding on oysters, and that the adult worm inhabited one of the large Elasmobranch fishes (Rays), which in their turn devour the *Balistes*. SHIPLEY and HORNELL have now identified as the adult *Tetrarhynchus unionifactor* a parasite that we found in *Rhinoptera javanica*,* the "Walwadi tirikkai" of

* SEURAT considers that the sting-ray *Aetobatis narinari*, EUPHRASEN, is the host of the pearl-inducing Cestode which he investigated in the Pacific. He does not state what evidence he has of this, but it is quite probable. We find the same species in Ceylon, where it is known as "Kuruvi tirikkai" by the natives, and it has an evil reputation on the pearl banks and many Entozoa in its interior. Its main food in Ceylon, as shown by the stomach contents, consists of sand-living Lamellibranchs, such as species of *Cardium* and *Venus*.

the Tamils (see this vol., p. 60, and Part III., Preface, p. viii). No fresh light has been thrown upon the possible occurrence of an immature stage in *Balistes* (which is eaten by the large rays), and although that intermediate host may not be necessary to the life-history, since the rays also feed upon pearl oysters, still there is nothing in the observed facts to forbid the existence of such a stage, and it is not unusual in Tetrarhynchids to have two fish-hosts, an intermediate Teleostean which is devoured by a final Elasmobranch.

Cyst and Pearl-Sac.

We now turn from the larvæ to the cysts which enclose them. In the youngest stages of both species these are merely thickenings of the connective tissue of the mantle (Plate II., figs. 17 and 18), or the mesoderm around the tubules of the liver, gonads, and other viscera. The thickening is laminated (Plate II., fig. 21), and the fibres, when fibres are visible in the lamellæ, run concentrically around the more or less spherical body of the larva. In the thicker cysts the outer layers may contain many blood spaces (lacunæ), and sometimes the thickening becomes quite spongy or œdematous (fig. 19). In some cases a considerable increase in the number of connective-tissue corpuscles or leucocytes is evident, and in later stages (Plate III., figs. 7 and 10) cells are sometimes seen to accumulate, and probably proliferate, along the inner surface of the fibrous cyst. It is just remotely possible that it is in this way that the pearl-producing epithelial sac is formed, from apparent mesoblast cells, inside the connective-tissue cyst. The other and more probable view that may be held is that these cells proliferating on the inner surface of the connective-tissue cyst are ectodermal in origin, and produce the pearl-sac.

As our specimens do not give conclusive evidence as to the stages in the formation of the epithelial sac, and as previous observers seem to have left this matter in some doubt, we think it advisable to state here fully the two possible alternative views that have been and may be held.

The first of these views is that the epithelial sac which surrounds the parasite and secretes the pearl is derived directly or indirectly from the ectoderm on the outer surface of the mantle—the layer which normally secretes the nacreous layer of the shell. By "directly" we mean where the sac as a continuous layer is formed by a pouching inwards of the ectoderm, the pouch being then cut off from the surface to form a closed sac. We should call "indirect" such cases as those where isolated ectoderm cells wandered into the mesoderm or were carried in by a moving parasite (the "processus cœnogénétique" of Giard); these ectoderm cells proliferating, it may be supposed, around the parasite to form the sac which then secretes the pearl.

In favour of this ectodermal origin may be stated :—

1. The very close resemblance between the epithelium of the pearl-sac and that of the outer surface of the mantle, amounting to identity in staining reaction.

Figs. 8 and 10, on Plate I., show examples of this from *Mytilus edulis*, where the sections were stained with eosine and methyl blue, and in both ectoderm and pearl-sac the cells and nuclei are of the same size and shape, and the nuclei are stained red with eosine and the cytoplasm blue to the same extent, so as to have a precisely similar appearance. In looking at a small part of the section under a high power, one receives the impression that the two adjacent epithelia are folds of the same layer (see Plate I., fig. 12). We show the same point in the case of the Ceylon pearl in fig. 16. Here the section is stained with gentian violet and light green, and in both ectoderm and pearl-sac the nuclei have taken up the violet, and the cytoplasm the green, to a quite similar degree.

2. The fact that pearls formed in different parts of the mantle have the character of the layers of the shell formed by the ectoderm in their neighbourhood—"horny" pearls, resembling the periostracum, have been found at the mantle edge; in the zone above that, pearls have been found having the characters of the prismatic layer of the shell; and finally, the great majority of pearls, both in the mantle and in the deeper tissues, show the structure of nacre, the layer produced by the greater part of the surface of the ectoderm on the mantle. It is difficult to account for these facts if the epithelium of the pearl-sac has no genetic connection with the layer of ectoderm lying outside it. The ordinary nacreous pearl is clearly produced in a similar manner to the inner part of the shell. The nacre is formed from epithelium on the outer surface of the mantle; the pearl from epithelium lining a closed sac. The most natural working hypothesis to hold until it is disproved, is that the epithelium of the closed sac is derived in some manner from the outer surface of the mantle.

Against this view, however, there is the notable fact that most recent investigators* have been unable to find any evidence of the pushing in of the ectoderm to form the pearl-sac. We may feel fairly certain, then, that the majority of pearls are not formed in actual pouches of ectoderm closed off from the mantle, as, if such structures were formed in any numbers, we could scarcely fail to obtain some evidence of their presence.

* The one definite exception to this statement is the case of M. L. BOUTAN, who, in his paper in 1904 ("Les Perles fines: leur origine réelle," 'Arch. Zool. Expér.,' 4 sér., tome ii., p. 47), describes and figures the actual pouching in of the ectoderm around the Distomid parasite to form cyst pearls in the case of *Mytilus edulis*. In this paper BOUTAN criticises adversely GIARD'S comments on our short note read at the Southport Meeting of the British Association in 1903; but our intention in that paper certainly was to express our belief in the ectodermal origin of the cyst pearls. When we stated "In all cases, whatever its nucleus may be, the pearl, like the nacre, is deposited by an epithelial layer," we intended to imply the ectoderm; and where, further on, we speak of "closed sacs," we meant to indicate that the ectodermal pouches alluded to in the previous sentence have become closed off. Professor GIARD interpreted our words correctly; and although in the present report we have discussed both possible views, still we have from the time of our first observations in Ceylon believed, as BOUTAN does, in the ectodermal origin of the cyst or "fine" pearls.

There still remains, however, the indirect connection, the possibility that, as the result of stimulation, cells from the outside of the mantle have migrated inwards to surround the parasite, or that the larva destined to form the nucleus of a pearl has in its wanderings carried in a few ectoderm cells which have eventually proliferated around it to form the pearl-sac. These would naturally be very difficult matters to prove, and the fact that no undoubted evidence of the migration, active or passive, of ectoderm cells in the case of the Ceylon pearl oyster has yet been found is not sufficient to disprove the possibility that the process takes place.

As a matter of fact there are some appearances in our sections that might be interpreted as indicating a migration of ectoderm cells (Plate I., figs. 18, 19, 20). When the pearl is in the mantle there is no great thickness of connective tissue between the ectoderm cells and the very similar epithelium forming the pearl-sac, and in some cases we have observed cells giving the same appearance and staining reactions in intermediate positions, and a few of these sub-epithelial cells are undoubtedly undergoing division (fig. 18). These may be regarded as wandering and proliferating ectoderm cells; we think they can scarcely be interpreted in terms of the other alternative—to which we now pass.

The second view that may be held is that the epithelium of the pearl-sac is formed from the neighbouring mesodermal connective-tissue cells modified *in situ* in response to the stimulation caused by the parasite. In favour of this view there is the absence of any direct evidence of the derivation of the cells from elsewhere, so that, so far as appearances go, the cells, although so very similar to those of the ectoderm, seem to arise from the tissue in which the parasite and pearl are placed—and in the present state of opinion amongst pathologists no one is likely to deny that indifferent mesodermal cells might become aggregated around a foreign body to produce an epithelial sac. Whether, however, we should be justified in imagining that such an epithelium might, under the stimulation of the parasite, produce layers of pearly material similar to the ectodermal nacre of the shell, is not so clear.

It is a distinct difficulty in the acceptance of this view that so many parasites in all parts of the body are merely surrounded by connective-tissue cysts, have no epithelial sac, and are apparently not being encased in pearls. If the pearl-producing epithelium can be formed *in situ* from connective-tissue elements, one would expect that every quiescent parasite which was becoming encysted would eventually be the centre of a pearl; but that does not appear to be the case. For one cyst pearl in our Ceylon material we find something like 100 encysted parasites, and these are surrounded by laminated connective tissue which may extend for several times the diameter of the parasite (Plate II., fig. 19).

Another strong reason against accepting this view is the point mentioned above, that pearls in different parts of the mantle present the characters of the ectodermal exoskeleton of their own neighbourhood. It would be difficult to understand that indifferent mesodermal cells could simulate specialised ectodermal cells to that extent.

In conclusion, then, we still adhere to the view we expressed in 1903, that in cyst pearls containing an organic nucleus the pearl-secreting epithelium is of ectodermal origin.

Muscle Pearls.

There are some pearls, however, that show no nucleus whatever, either organic or inorganic, and it seems probable that these have been formed by the deposition of calcareous matter around a minute calculus in the tissues. These are the pearls that we have distinguished ('Brit. Assoc. Report, Southport,' p. 695) as "Muscle pearls," since we find them most abundantly in the muscular tissue near the insertions of the levator and pallial muscles. Figs. 5A and 5B, illustrate the distribution of cyst pearls

Fig. 5A. Diagram showing the comparative frequency of position of cyst pearls in the various parts of the mantle.

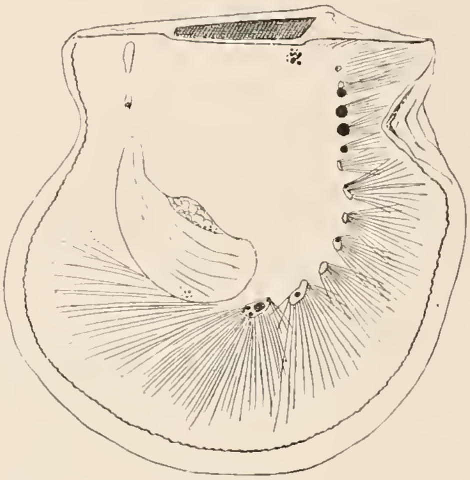


Fig. 5B. Diagram showing the positions most frequently occupied by muscle pearls.

and muscle pearls respectively, the localities most commonly occupied by the pearls being indicated by spots. Figs. 13 and 14 on Plate III. show also the mode of occurrence of the muscle pearls near the insertion scars.

The muscle pearls when present are usually abundant,* and when examining under the microscope a young pearl of this kind, *in situ*, it is common to find a large number of minute calcareous depositions, or calcospherules (Plate III., fig. 12), scattered in the neighbouring tissue. It is probable that the muscle pearls are formed around these microscopic calcospherules as centres of irritation, and as these positions are invariably in our experience close to the surface of the muscle or the mantle, there is no difficulty in understanding that there, if anywhere, ectoderm cells might migrate to the source of irritation and thus be responsible for the deposition of a pearl.

* At the insertion of one levator muscle, 23 small pearls were counted with the eye, while under the microscope 170 additional tiny spherules were found to be present.

CONCLUSIONS ON PEARL-FORMATION.

We may now sum up our views as to pearl-formation in the Ceylon pearl oyster as follows (using with but slight changes and additions the wording of our 1903 note* on the subject) :—

1. The majority of pearly excrescences on the interior of the shell are due to the irritation caused by *Clione*, *Leucodore*, and other boring animals. In exceptional cases a free pearl may be formed in this way.

2. Minute grains of sand and other inorganic particles only form the nuclei of pearls under exceptional circumstances. Probably it is only when the shell is injured, *e.g.*, by the breaking of the "ears," thus enabling sand to get into the interior, that such particles supply the irritation that gives rise to pearl-formation. The ectoderm, in such cases, would probably also be damaged, and cells may be carried in with the inorganic particles.

3. Many pearls are found in the muscles close to the surface, especially at the levator and pallial insertions, and these are formed around minute calcareous concretions, the "calcospherules," which are produced in the tissues and form centres of irritation. These are, in all cases, close to the surface of the mantle, or even in contact with the ectoderm.

4. Most of the fine pearls found free in the body of the Ceylon oyster contain the remains of Cestode parasites, so that the stimulation which leads to the formation of an "orient" pearl is, as has been suggested by various writers in the past, due to the presence of a minute parasitic worm. Probably in all cases, whatever its nucleus may be, the pearl, like the nacre, is deposited by an epithelial layer derived from the ectoderm.

These four categories are separated according to the cause of the stimulation. The first set, however, can scarcely be considered as "pearls," and the others may be conveniently classified under the following three names :—

I. *Ampullar-pearls*, where the nucleus and resulting pearl lie between the shell and the body, or in a pouch (the ampulla) of the ectoderm projecting into the mantle. The others lie in closed (ectodermal) sacs.

II. *Muscle pearls*, formed around calcospherules near the insertions of muscles.

III. *Cyst pearls*, formed around encysted parasites. The parasite in the case of the majority of the cyst pearls of Ceylon is the larva of one or more species of Cestodes, belonging to the genus *Tetrarhynchus*.

It seems possible that in *Placuna placenta*, the "vitre chinoise" or window oyster of Tampalakam Lake near Trincomalee, a Distomid parasite which we find in the tissues both free and encysted, may also occasionally be a cause of pearl-formation.

* 'British Association Report, Southport,' p. 695.

The encysted Cestode larvæ found in the pearl-oyster are, however, also present in *Placuna*—sometimes in great numbers, so as to be densely crowded together in the superficial layer of the mantle, as shown in fig. 6. Compound cysts, where one larva occurs within the vesicle of another, are sometimes seen. Similar larvæ, both alive and as nuclei of pearls, are also found in specimens of *Placuna placenta* from the Gulf of Kutch.* In fact, a fuller experience is causing us to incline to the view that various parasites may act as pearl nuclei even in the same mollusc. Some pearls are certainly formed round intrusive Nematodes. We have a complete cyst pearl, free and unattached, of which the nucleus is a coiled *Cheiracanthus uncinatus*, on which the pearl deposit is not sufficiently thick and opaque to obscure the coils so as to render identification difficult.

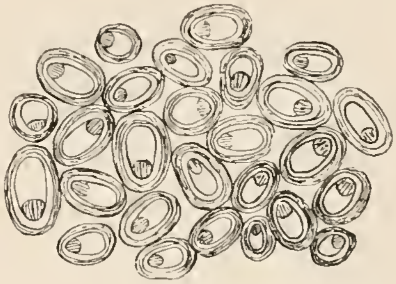


Fig. 6. Aggregation of encysted Cestode larvæ in the mantle of *Placuna placenta*; magnified.

But although KELAART's statement, half a century old, that various kinds of worms are concerned in pearl-formation may be correct, still we hold that our investigation has shown that in *Margaritifera vulgaris*, at Ceylon, the production of the orient pearl is dependent upon Cestode infection and that the species mainly concerned is *Tetrarhynchus unionifactor*.

The next question that naturally arises is—Can we profitably follow up KELAART's suggestion that it might be possible to increase the number of pearls by infecting the molluscs with the appropriate parasites? This "margarose artificielle" has been tried, as we have shown above, by DUBOIS in a case where the parasite was supposed to migrate from one mollusc (a *Mytilus*) to another of a different genus (*Margaritifera*). GIARD and others have pointed out the difficulties in the way of accepting this case, and the doubts that naturally arise; and we are probably correct in concluding that the method has not as yet resulted in a marked success on the southern coast of France; although it is quite possible that similar methods with other shell-fish elsewhere may give good results.

On the Ceylon pearl banks, however, it is probably quite unnecessary to take any steps to ensure infection with the appropriate parasite. Oysters, wherever they appear, when they are old enough contain pearls, and encysted parasites are even more abundant. Even when new beds are formed artificially by transplanting to unoccupied ground, as we do not doubt will be the case in the future, that operation may be carried out with perfect confidence that when the four-year-old oyster is fished it will contain the normal† supply of pearls. The parasites are probably so widely spread that every pearl oyster in the Gulf of Manaar, or, for that matter, around the coast of Ceylon, runs a fair chance of becoming infected. Cyst pearls are found in the

* See HORNELL's Reports from the Ceylon Marine Biological Laboratory, Part II., 1906.

† Of course some beds are richer in pearls than others and some years are better than others.

oysters at Trincomalee ; the fishes that are, in all probability, the hosts of the parasite in its more advanced stages abound at various points. It is the molluscan host and not the parasite that stands in need of artificial aid in Ceylon. If we can increase the number of beds, and can prevent catastrophes from devastating the oyster populations, so that the divers can collect them annually in their tens of millions, we need not fear any scarcity of pearls.

As BOUTAN, who thinks favourably of artificial methods, points out* :—" Mais il ne faut pas oublier que l'infection d'un animal par un parasite ne favorise pas précisément le développement normal du sujet infesté." He advocates as an alternative method experimental trepanning of the shell, but that or any other mode of individual treatment is clearly impracticable in dealing with the millions of the Ceylon pearl banks. Our own opinion is that, although all pearl-production is a departure from the normal, the pearl-inducing parasites are not sufficiently abundant to affect seriously the health of the oyster ; and that, to reverse the popular saying, if we attend to the prosperity of the bed as a whole, the individual oysters may be left to take care of themselves, both in regard to health and pearl-production.

DISTRIBUTION OF PEARLS.

Figs. 5A and 5B, on p. 27 show the usual distribution of cyst and muscle pearls respectively in the Ceylon pearl oyster. The following table will show the numerical proportion between the two kinds in various parts of the body. It is the summary of a number of observations made by us in 1902 and 1903 :—

Locality.	Number of oysters dissected.	Cyst pearls—		Muscle pearls at insertion of —				Total pearls.
		In mantle lobe outside the pallial line.	Within the pallial line.	Levator muscles.	Palpar pallial muscles.	Other pallial muscles.	Adductor and retractor.	
South-east Cheval . .	378	7	10	48	9	4	6	84
Mid-east Cheval . .	450	19	10	13	4	1	—	47
North-east Cheval . .	266	7	2	11	3	—	—	23
Periya Paar Karai .	168	6	3	10	1	1	—	21
West Cheval . . .	83	2	1	—	1	—	—	4
Dutch Modragam . .	17	—	—	—	—	—	—	0
Muttuvaratu . . .	38	2	—	—	—	—	—	2
Totals	1400	43	26	82	18	6	6	181

* 'Arch. de Zool. expér.,' 1904, p. 89.

As these two classes of pearl differ not only in value but in mode of occurrence, it is worth while to contrast their distribution more definitely. If we unite the subdivisions of the pearl-classes, we find the proportions to be :—

Locality.	Number of oysters dissected.	Number of cyst pearl-bearers.	Number of muscle pearl-bearers.	Total number of pearl-bearers.	Percentage of cyst pearls.	Percentage of pearl-bearers of both classes.
South-east Cheval . .	378	17	67	84	4·5	22·2
Mid-east Cheval . . .	450	29	18	47	6·4	10·4
North-east Cheval . .	266	9	14	23	3·4	8·6
Periya Paar Karai . .	168	9	12	21	5·4	12·5
Western Cheval . . .	83	3	1	4	3·6	4·8
Dutch Modragam . .	17	—	—	—	—	0·0
Muttuvaratu	38	2	—	2	5·3	5·3
Total	1,400	69	112	181	—	—

From this it is seen that of the 1,400 oysters, aged from 3 to 3¾ years, which were individually dissected with the greatest care, only 181 proved to be pearl-bearers, equal to a percentage of 13.

A remarkable feature of these and other observations we have on record is the relatively great abundance of individuals upon the South-east Cheval containing muscle pearls. On the other hand, as the value of the oysters is chiefly dependent upon the proportion of cyst pearls present, these oysters appeared to be commercially inferior to those of the Mid-east Cheval—a conclusion subsequently proved correct by the actual returns obtained from these two banks during the course of the Fishery of 1903. The proportion of muscle pearls for the South-east Cheval at that fishery was over 90 per cent. Of 94 pearls dissected out, only 9 were cyst pearls.

Whatever may be the cause of certain pearl oysters containing exceptionally large numbers of muscle pearls, it is worthy of note that the vigorous and healthy oysters of the Eastern Cheval and Periya Paar Karai produced practically all the examples of this class of pearls, there being 111 muscle pearl-bearers from these banks out of 1,262 oysters, whereas the 138 oysters from the beds characterised by stunted growth—the Western Cheval, Dutch Modragam, and Muttuvaratu paars—gave but a solitary instance of this class.

The variation in the number of cyst pearls is due, ultimately, to the relative abundance of the pearl oysters on different grounds and of the *Tetrarhynchus* larvæ that cause pearl-production, and that ratio must be affected amongst other factors by the abundance of the fish-host of the sexually mature Cestode.

We give now another tabular statement obtained more recently :—

Pearl-yield of Representative Samples of Oysters (over 3½ Years Old) Examined in November, 1905.

Name of bank.	Number of oysters examined.	Cyst pearls. Number of cyst pearls.	Cyst pearls. Individuals containing cyst pearls.	Cyst pearls. Percentage of cyst pearl-bearers.	Muscle pearls. Muscle pearls found.	Muscle pearls. Individuals containing muscle pearls.	Muscle pearls. Percentage of muscle pearl-bearers.	Pearl bearers, both cyst and muscle.	Percentage of total pearl-bearers to total examined.
South-east Cheval .	180	44	34	18·888	171	54	30	88	48·333
,, ,, .	180	22	16	8·888	49	18	10	34	18·888
North Modragam .	225	13	13	5·777	90	31	13·777	44	19·554
South ,, .	67	8	6	8·955	29	10	14·925	16	23·880
Kutiramalai . . .	28	7	5	17·857	26	5	17·857	10	35·714
Mid-west Cheval .	21	4	3	14·285	2	1	4·762	4	19·047
,, ,, .	200	13	11	5·500	63	22	11·000	33	16·500
Muttuvaratu . . .	30	Nil	Nil	Nil	16	5	16·666	5	16·666
,, . . .	140	9	9	6·428	40	18	12·857	27	19·285
,, . . .	420	10	9	2·143	106	41	9·762	50	11·905
Total . . .	1491	130	106	7·109	592	205	13·749	311	20·858

The following table shows the positions in the body and the weights of certain of the above pearls :—

Location and Weight of Pearls from the same Representative Samples.

Name of bank.	Location of cyst pearls. Peripheral region of mantle.	Location of cyst pearls. Central region of mantle.	Weight of the larger cyst pearls in grammes.	Weight of small cyst pearls plus all the muscle pearls in grammes.
South-east Cheval	12	32	22 largest = 1·050	44 cyst and all muscle pearls
,, ,,	10	12		(264 in all) weighed 1·480
North Modragam	1	12	4 ,, = 0·250	9 cyst and 90 muscle pearls, 0·510
South ,,	5	3	3 ,, = 0·045	5 ,, 29 ,, 0·105
Kutiramalai . .	1	6	3 ,, = 0·300	4 ,, 26 ,, 0·170
Mid-west Cheval .	1	2	Insignificant	Insignificant
,, ,, .	4	9	6 largest = 0·120	7 cyst and 63 ,, 0·380
Muttuvaratu . .	Nil	Nil	Nil	16 ,, 0·100
,, . .	8	1	5 cyst pearls = 0·290	3 cyst and 40 ,, 0·220
,, . .	5	5	Not taken	Not taken
Total . .	47	82	43 cyst pearls = 2·055	72 cyst plus 484 muscle pearls, 2·965

NATIVE CLASSIFICATION OF PEARLS.

It may be useful if we place on record here the native system of classification of pearls, which is supposed to be of extreme antiquity and is still made use of in Government reports, at the fisheries and by the pearl merchants.

We may conveniently give the procedure of the native in classifying his pearls in the words of CORDINER*—one of the earliest English writers on the subject, as his observations were made on the fisheries which took place at the beginning of last century, under the Government of Lord GUILDFORD.

"After the pearls are separated from the sand, washed with salt water, dried, and rendered perfectly clean, they are sorted into classes according to their sizes, by being passed through ten brass sieves or saucers full of round holes. The saucers are apparently all of one size, but made so as to go in within one another. They are distinguished into numbers, 20, 30, 50, 80, 100, 200, 400, 600, 800, and 1000. This is a kind of ratio to estimate the value of the different sizes of pearls; and probably the distinguishing numbers, in some measure, correspond with the quantity of holes in each basin. These completely occupy the bottom of the vessel; and as they increase in number, necessarily decrease in size. The pearls are thrown in a promiscuous heap into the uppermost sieve, which being raised a little and shaken, the greater part of them pass through into the second sieve, and only those remain which exceed a large pea in size. The second sieve is shaken in the same manner; the pearls that remain in it are of the size of a small pea, or grain of black pepper. The quantity of pearls gradually increases as the size diminishes. Those which fall through the tenth saucer (No. 1000) belong to the class of Tool, or seed pearls, so called from the smallness of their size.

"I saw this operation of sorting the pearls performed with the produce of seventeen thousand oysters, which only weighed three-quarters of a pound, and was contained in a vessel smaller than a common soup-plate. Out of that quantity there were not found two perfect pearls, either of the first or second order. About twenty or thirty pearls remained in these saucers, but almost all of them were slightly deformed, rugged, and uneven. Of the smaller sizes many were round and perfect.

"The pearls contained in the sieves from No. 20 to 80, inclusive, are distinguished by the general name of Mell, or the first order. Those of the sieves from No. 100 to 1000 are denominated Vadivoo, or the second order. Both these orders are divided into various sorts, according to their shape, lustre, and other qualities; amongst which are Annees, Annadaree, Kayerel, Samadiem, Kallipoo, Koorwel, Pesul, and Tool. The Annees are the first sort, perfectly round, and of the most brilliant lustre. Annadaree is a sub-division of them, possessing the same qualities in an inferior degree. Kayerel is the next in beauty, but not so completely round, and of a duller

* 'Description of Ceylon,' London, 1807, vol. ii., p. 62.

colour. To this class belongs the Samadiem, which is nearly of the form of a pear, and the Kallipoo, which has flat sides. The Koorwel, or third class, is a double pearl, ill-shaped, and of a dull water; to it may be added the Pesul, the most deformed of all the pearls; and the Tool, the most diminutive."

From the above it will be seen that CORDINER could get no definite information as to the numbering of the ten sieves, viz., 20, 30, 50, 80, 100, 200, 400, 600, 800, and 1000. Sir WILLIAM TWYNAM informs us that these numbers indicate that so many pearls from such sieves stand to a "Kalanchu." We show here in fig. 7, A and B, the impression, natural size, of the bottoms of the two extreme sieves of the series, 20 and 1000, kindly supplied to us by Sir W. TWYNAM.

As regards sieve No. 1 (the 20 sieve, fig. 7, A), it is, of course, only the pearls which just escape going through the sieve that can be taken into account in making the estimate. Large pearls of more than ordinary value are regarded as exceptional, and are not taken into account in valuing samples. It is said that the native merchants judge the value of samples chiefly by what remains in the No. 4 (80 sieve).

This account of the methods in use a hundred years ago applies perfectly at the present day (as may be seen from the modern valuation form we print below, p. 38) except for some slight changes in the spelling of the names. We give now a list of the classes of pearls distinguished by the native valuers and merchants, with some indication of the meaning of the name and any other information* we have as to the kind of pearl. The list begins with the finest class of pearls and ends with the poorest. In each case we give first the Tamil name written in English, according to the Government spelling, then the literal meaning of the word, to which may be added the more extended meanings in present usage, the size, shape and other characters, followed by any peculiarity in use or native estimation. It will be noticed that some of the terms, such as "Mel" and "Tul," indicate relative size, while others, such as "Ani," apply to quality, or, such as "Kuruval" and "Kodai," to shape and colour.

"MEL" or "MEL-MUTTU," meaning "upper," or superior pearl. This is a term of size, not of quality, and applies to pearls retained in the 20 to 80 sieves.

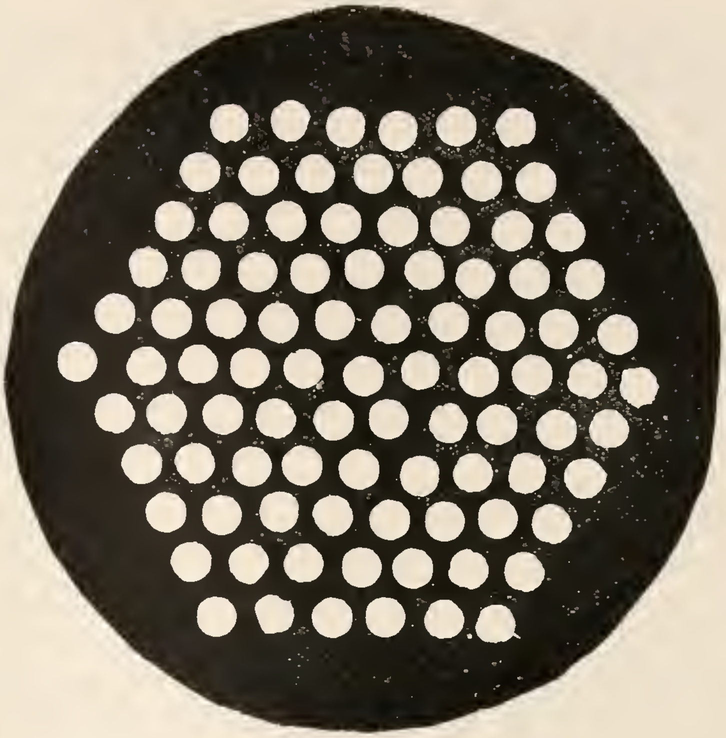
"ANI," meaning "best"; excellent—a fine, superior pearl both as regards quality and perfectly spherical shape, of the best lustre and colour, the true "orient" pearl.

"ANATARI," meaning "follower" or "second"; a pearl closely approximating to the Ani, but with some slight departure from perfection, such as a speck or a flattening on one side.

"KALIPPU," meaning "rejected," or inferior to Anatari; a good pearl, more or less symmetric, may be lens-shaped or oblong, usually flattened.

* We are indebted for some of this information to Sir WILLIAM TWYNAM, of Jaffna, who has been most kind in supplying us with details as to former fisheries and native methods, both during our expedition in 1902 and also on occasions since.

A.



B.

Fig. 7. Impressions of the largest and the smallest of the pearl merchants' ten sieves. **A**, the 20 sieve or basket; **B**, the 1000 sieve or basket.

"KURUVAL," meaning "short"; deformed and double pearls, but not necessarily inferior in quality, may be of excellent lustre but of irregular form. "Ani-Kuruval" is where two Ani are partially fused together, whether the pearls be of equal size or not; but each must be so formed that if not fused it would be spherical. "Pisal-Kuruval" is where several pearls of good lustre and colour are partially and irregularly fused together. "Pampara-Kuruval" is a pearl grooved regularly, like a top.

"KAYARAL," meaning "the clasp of a necklace"; a dark-coloured treble pearl, not completely round, and of a dull colour.

"SAMADIAM," a pearl with a reddish tint, pear-shaped, but of a dull colour.

"NIMELAI," a nose-pearl, a perfect-skinned, pear or egg-shaped pearl.

"SIRIPPU," a pearl grooved with irregular wrinkle-like furrows.

"MASAKU," badly coloured pearls; usually grey, but symmetrical and with lustre.

"PISAL," meaning "torn"; a deformed pearl or cluster of small misshapen pearls of little or no value, of bad colour, usually slag-like in appearance.

"KODAI," meaning "brown"; like a nut, with no nacreous lustre, formed of prismatic shell, may be large and is usually spherical and includes pearls of different colours, and those white ones that have black or brown marks. "Van-Kodai" is a Kodai pearl with one side nacreous. "Karunk-Kodai," a black or blue-black slag-like pearl.

"VADIVU," meaning "beauty"; also "decreasing"; that which is strained or sifted, an intermediate pearl, found in the 100, 200 and 400 sieves. These small pearls of regular form, good colour, and lustre, are what are held in most general esteem in the East.

"MADANKU," meaning "folded or bent"; all pearls of Vadivu size that are imperfect in form or colour.

"TUL," meaning "powder"; the seed-pearls, smallest size, those that are retained by the 600, 800 and 1000 sieves.

"MASI-TUL," meaning "ink-dust" or chalk powder; smaller than the 1000 sieve. These are generally used for medicinal purposes or burnt and used as chunam to be eaten with areca nut and betel by the natives.

"ODDU" or "OTTUMUTTU," meaning "shell-pearl"; an attached pearl or nacreous excrescence on the inside of the shell.

If we consider only the size of the pearls as separated out by the sieves, we find :—

"Mel-muttu" in the 20 to 80 sieves;
"Vadivu" and "Madanku" in the 100, 200 and 400 sieves;
"Tul" in the 600, 800 and 1000 sieves; while
"Masi-Tul" are those that pass through the finest sieve.

Considered from the point of view of perfection in lustre and quality generally,

the "Mel-muttu" or large pearls are grouped as "Ani," "Anatari," "Kalippu," "Kuruval," &c.; while some of the remaining terms refer to special abnormalities or unusual shapes and colours.

As may be seen from the valuation form printed below, "Kalippu," "Kuruval," "Pisal," "Kodai" and other inferior classes may be of large size and so occur along with "Ani" and "Anatari" amongst the "Mel" in the 20, 30, 50 and 80 sieves.

As showing the relative abundance of the three grades of good pearls comprised under the head of "Vadivu," those obtained from the washing of 11,000 four-and-a-half year old oysters from the South-east Cheval Paar in November, 1905, were found to be as follows:—

	108 pearls of the	100 basket size	(weight	$11\frac{8}{32}$	Manchadi)
	154 ,,	200 ,,	(,,	$9\frac{11}{32}$	,,)
	253 ,,	400 ,,	(,,	$9\frac{10}{32}$	,,)
Total	515				

Finally we print here a sample of the official valuation given in the 'Ceylon Government Gazette,' previous to a fishery, as the result of the examination (by the Inspector, the local Adigar, and three native pearl merchants) of the samples of oysters lifted from the banks during an inspection (see p. 38).

Kalanchu (corruptly Kalangi) and Manchadi are weights, there being 20 Manchadi (originally the scarlet seed of a plant) of 0·546 gramme each in the Kalanchu, which thus weighs 10·920 grammes. Now the Manchadi has been standardised and is a tabular brass weight of square form. The fractions and multiples represented by the little brass weights commonly employed by the Tamil pearl merchants range from the $\frac{1}{32}$ of a Manchadi to 10 Kalanchu.

The Chevoe, used in the valuation of the finest pearls, is an imaginary criterion depending partly upon weight and partly upon quality, and the valuers have to estimate how many such chevoe there are in each of the Ani and Anatari grades of pearl in the sample.

Bombay and Surat merchants as a rule do not employ the brass weights favoured by the Tamil merchants. They prefer beautifully modelled, pear-shaped weights of agate—sometimes red, sometimes greyish-white in colour. A rupee weighs approximately $1\frac{1}{16}$ Kalanchu.

The monetary basis employed in the calculation of values is the Star pagoda, a small plano-convex gold coin that was the standard gold currency in South India less than one hundred years ago. Its nominal value in the calculations made is Rs. $3\frac{1}{2}$. So if Masi-tul be valued at two star pagodas a Kalanchu, this indicates the market value to be Rs. 7 per Kalanchu. It should be noted that although the nominal value of the star pagoda is taken for the purpose of calculation at but Rs. $3\frac{1}{2}$, its intrinsic value as a gold coin at the present rate of exchange is considerably greater, being worth fully Rs. 6 as gold.

STATEMENT of the Valuation and Produce of 12,000 Oysters taken from the South-west Cheval Paar in February, 1904.

Description.	Size in basket.	Number.	Quantity in Chevoe.	Kalanchu.	Manchadi.	Total. Kalanchu.	Total. Manchadi.	Value.	Total value.	Per Chevoe.	Per Kalanchu.
								Rs. c.	Rs. c.		
Ani	20	1	25/320	—	5/16			12 58		50 pagodas	—
Anatari	20	1	60/320	—	1/2			19 68		30 "	—
Kalippu	20	2	—	—	1			5 25		—	30 pagodas
Kuruval . . .	20	2	—	—	3/4			1 31		—	10 "
Pisal	20	7	—	—	3½			1 83		—	3 "
Kodai	20	3	—	—	1¼		7 5/16	0 21	40 86	—	1 pagoda
Ani	30	5	106/320	—	1½			42 87½		40 pagodas	—
Kalippu	30	7	—	—	2⅛			7 44		—	20 pagodas
Kuruval	30	5	—	—	1¾			3 6		—	10 "
Kodai	30	4	—	—	1		6 6/16	0 17½	53 55	—	1 pagoda
Anatari	50	3	25/320	—	9/16			8 22½		30 pagodas	—
Kalippu	50	7	—	—	1½			5 25		—	20 pagodas
Kuruval	50	10	—	—	2½			5 25		—	12 "
Pisal	50	3	—	—	3/4			0 39		—	3 "
Kodai	50	4	—	—	3/4		6 1/16	0 13	19 24½	—	1 pagoda
Ani	80	9	40/320	—	1¼			21 87½		50 pagodas	—
Anatari	80	6	40/320	—	1			13 12½		30 "	—
Kalippu	80	17	—	—	2½			8 75		—	20 pagodas
Kuruval	80	21	—	—	4¼			8 92½		—	12 "
Pisal	80	6	—	—	1			0 52½		—	3 "
Kodai	80	3	—	—	1/2		10 5/16	0 8½	53 28½	—	1 pagoda
Vadivu	100	—	—	—	18					—	—
Vadivu	200	—	—	—	19					—	—
Vadivu	400	—	—	—	18	2	15	192 50	192 50	—	20 pagodas
Tul	600	—	—	1	5					—	—
Tul	800	—	—	—	17					—	—
Tul	1,000	—	—	—	10	2	12	63 70	63 70	—	7 pagodas
Masi-tul . . .	—	—	—	—	16		16	7 0	7 0	—	2½ "
Shell-pearls . .	—	—	—	—	—			2 0	2 0	—	—
					Totals .	7	13 4/16		432 14		

Equal to Rs. 36·01 per 1,000 oysters.

JAMES HORNELL, Inspector of Pearl Banks.
V. VRASPILLAI, Adigar, Musali.
.................., Valuer.
.................., Valuer.
.................., Valuer.

Marichchikaddi,
March 9, 1904.

South Indian pearl merchants make constant use, in working out their valuations, of a useful Pearl Merchants' "Ready Reckoner," published in 1890 at Tondimundalam, Madras, under the name of "Pearl-calculating Tables." It is printed wholly in Tamil, and gives the number of chevoe for a certain weight in Kalanchu and Manchadi of special classes of pearl. That obtained, the valuers fix the estimate according to what they agree shall be considered the market price of the day per chevoe of this quality. It may be accepted that this figure given in the official valuation is always considerably under the true ruling price of the day, and at the auctions during the fishery that follows, the oysters always sell at far above the estimate given in this valuation.

It is possible that with the advent of the London syndicate, to which the Ceylon pearl fisheries have been leased for the next twenty years, these picturesque old-time native methods, which have survived through the Portuguese, Dutch and British administrations, may now give place to more exact modern financial requirements. We are glad to have had this opportunity of putting on record a system which, existing, it is said, at the time of the "Periplus of the Erythræan Sea," has come down to our own day, practically unaffected by European civilisation, and may before long be doomed to disappear.

Pearl merchants.—From a photograph by J. Hornell.

EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1. Part of a gill lamella of *Mytilus edulis*, showing a larger pearl occupying the whole thickness of the lamella and a smaller one in an enlarged gill filament. × 40.

„ 2. Group of four pearls in the mantle of *Mytilus edulis*—two of the pearls being in one sac. × 40.

„ 3. Pearl from the mantle of *Mytilus edulis*, showing a small, but quite simple nucleus, evidently, from its staining, an organic particle, but having no visible structure. × 40.

„ 4. Pearl from the mantle of *Mytilus edulis*, showing a relatively very large, deeply stained, but disorganised nucleus. × 40.

„ 5. Pearl from the mantle of *Mytilus edulis*, showing no nucleus, no cavities, and no foreign structure. × 100.

„ 6. Pearl and Trematode lying together in the mantle of *Mytilus edulis*. × 40.

„ 7. Pearl (with several centres) and Trematode lying together, enclosed in the same sac, in the mantle of *Mytilus edulis*. × 40.

„ 8. Pearl in a gill lamella of *Mytilus edulis*, showing a very large, disorganised nucleus, and a distinct sac, with epithelium closely resembling that of the adjacent ectoderm. × 300.

„ 9. Pearl from *Mytilus edulis*, decalcified to show the layers of conchiolin. × 40.

„ 10. Portion of a pearl and its sac (*p.s.*) from the mantle of *Mytilus edulis*, to show the similarity between the epithelium and the ectoderm (*Ect.*). × 300.

„ 11. Another portion of a pearl and its epithelial sac from the mantle of *Mytilus edulis*, to show irregularly projecting parts of the pearl cut separately. × 300.

„ 12. Adjacent portions of pearl sac and ectoderm from fig. 10, to show similarity. × 1000.

„ 13. Section through a Ceylon pearl in the natural condition. × 40.

„ 14. A partially decalcified pearl in the mantle of the Ceylon pearl oyster. × 100.

„ 15. Section through a partially decalcified Ceylon pearl. × 100.

„ 16. Portion of pearl sac and adjacent ectoderm of Ceylon pearl, to show similarity. × 1000.

„ 17. Portion of a Ceylon pearl and its epithelial sac. × 200.

„ 18 Portion of Ceylon pearl and its epithelial sac and mantle, to show large clear cells. × 900.

„ 19. Ceylon pearl and mantle, to show the large clear cells in the ectoderm (B) and in the pearl sac (A). × 900.

„ 20. Mantle of Ceylon pearl oyster over a pearl, to show the distribution of the large clear cells. × 900.

PLATE II.

Fig. 1. Margin of mantle of a highly infected Ceylon pearl oyster from Muttuvaratu Paar, showing nine encysted Cestode larvæ. Natural size.

„ 2. Transverse section through viscera of Ceylon pearl oyster, showing four Cestode cysts in the liver. Slightly enlarged.

„ 3. Gill filaments of Ceylon pearl oyster, showing encysted Cestode larva. × 12.

„ 4. A. Outline of a cyst pearl for comparison with B. Outline of the Cestode larva that forms the pearl-nucleus. × 20.

Fig. 5. Nucleus of a decalcified cyst pearl from the posterior ear-region of a Cheval Paar oyster, showing the characters of the Cestode larva. × 20.

" 6. Partially calcified cyst around a dead Cestode larva, from the mantle of a 3-year-old Muttuvaratu Paar oyster. × 20.

" 7. Nucleus of a decalcified cyst pearl from the mantle of a Cheval Paar oyster, showing a Cestode larva with a spherical calcification in its interior. × 20.

" 8. Young Cestode larva (*Tetrarhynchus unionifactor*), extracted from thick-walled cyst in mantle of pearl oyster. × 40.

" 9. Young *Tetrarhynchus* larva, extracted from a cyst in the mantle, showing the spines upon the "collar." × 40.

" 10. The same, seen after slight pressure has caused the evagination of the "head." × 40.

" 11. Another slightly later stage, seen under slight pressure. × 60.

" 12. Rather later stage of the larva, showing elongation of body; from a cyst in viscero-pedal part of pearl oyster. × 30.

" 13. Encysted later larva of *Tetrarhynchus pinnæ*. × 10.

" 14. Later larva of *Tetrarhynchus pinnæ*, freed from the cyst-membrane. × 10.

" 15. Late larva of *Tetrarhynchus balistidis*, from the liver of the File-fish, which eats pearl oysters. Natural size, and "head" × 16.

" 16. The latest larval stage of *Tetrarhynchus unionifactor* met with in the pearl oyster. × 30.

" 17. Part of the liver of the pearl oyster, showing one of the smaller (A) and one of the larger (B) Cestode larvæ encysted in the connective tissue. × 50.

" 18. Globular larval Cestode encysted in the connective tissue of the liver. × 300.

" 19. One of the smaller larvæ (*Tetrarhynchus* sp.) surrounded by a very thick connective-tissue cyst, showing a laminated structure. × 50.

" 20. Larva in the same stage, showing the division of the muscle masses into incipient bothridia, or proboscides. × 300.

" 21. Another larval stage, surrounded by a dense connective-tissue cyst. × 300.

" 22. Another similar larva, slightly younger, showing a very slight cyst. × 450.

PLATE III.

Fig. 1. Section of larva of *Tetrarhynchus unionifactor*, showing an unusually depressed head. × 300.

" 2. Section of another larva, showing the usual protruding papilla. × 960.

" 3. An oblique section, × 40—showing the developing muscular tissue at *a* enlarged.

" 4. Another oblique section, showing lateral muscular thickenings. × 40.

" 5. Section through a larva, showing infoldings on the head. × 40.

" 6. Section of the usual form, with large muscular protruding head. × 40.

" 7. Posterior end of the last section, showing details. × 300.

" 7A. Details of the fibres and spines on the cuticle of the last, more highly magnified.

" 8. Typical longitudinal section through the larva of *T. unionifactor* as seen commonly encysted in the pearl oyster. × 960.

" 9. Group of hooks *in situ* from the cuticle on the anterior invagination of the larger Cestode larva (*T. unionifactor*); with enlarged outlines of two isolated hooks. × 1000.

" 10. Section through a very young *Tetrarhynchus*, with the four proboscides; from cyst between stomach and liver in pearl oyster. × 50.

" 11. Section through more elongated *Tetrarhynchus*, also from a cyst *in situ* in the viscera of the pearl oyster. × 50.

Fig. 12. Three calcospherules from the insertion of anterior levator muscle; a, simple; b, compound; c, optical section showing pearl layers (*a*) being deposited round calcospherule.

,, 13. Diagram showing position of two irregular compound muscle pearls in 2nd and 3rd pallial muscle insertions; *a* and *b* show the two pearls, slightly enlarged.

,, 14. Diagram showing two rows of muscle-scars, the outer being the present functional ones; *a* marks the position of a muscle-pearl on the site of a former muscle-insertion (palpar region).

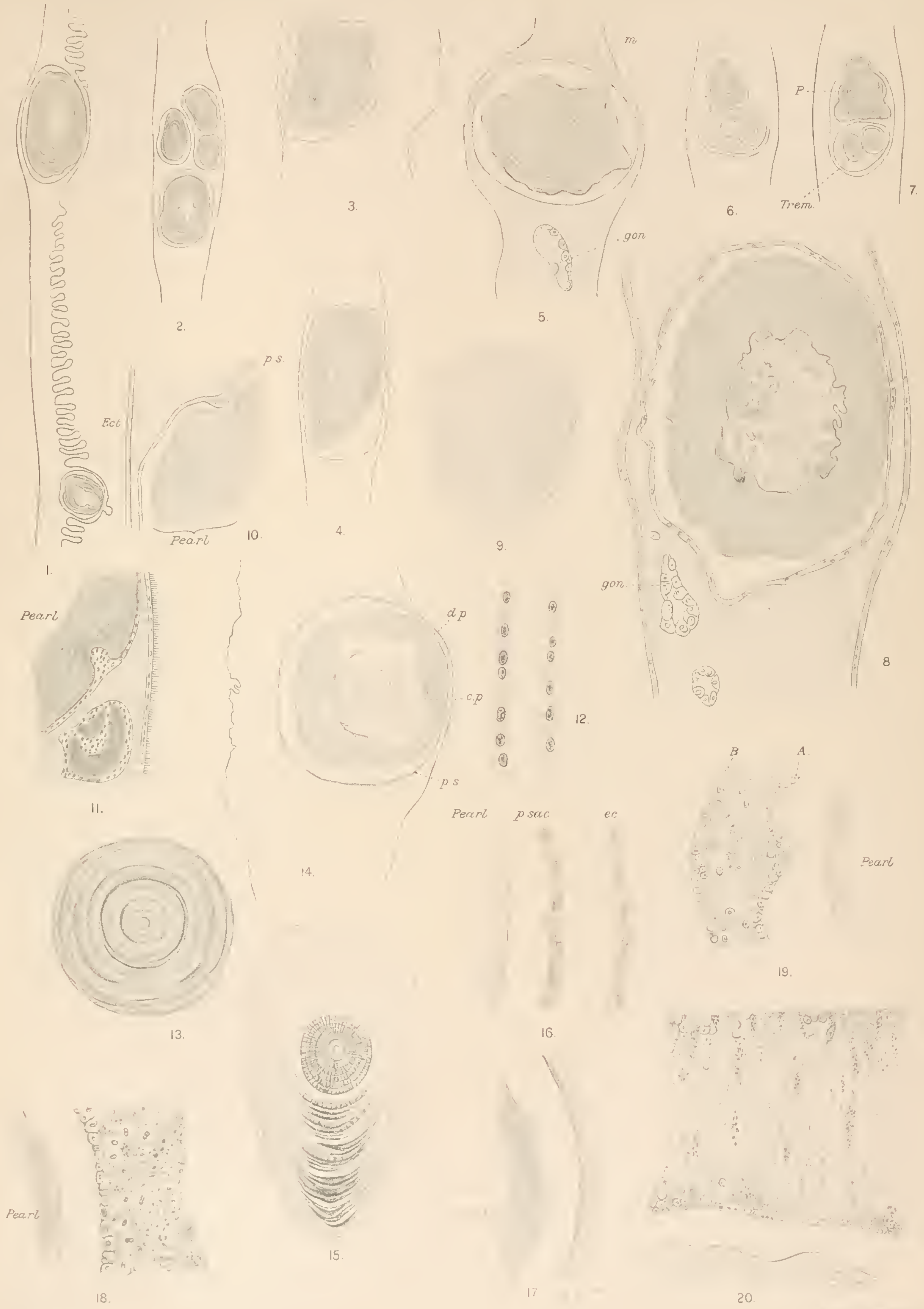
,, 15. Six cyst pearls in the mantle of the posterior ear, left side; four others lay in a corresponding position on right side.

,, 16. Two cyst pearls in mantle, posterior to dorsal end of adductor muscle.

,, 17. Six cyst pearls, misshapen through mutual pressure, in the mantle of the posterior ear.

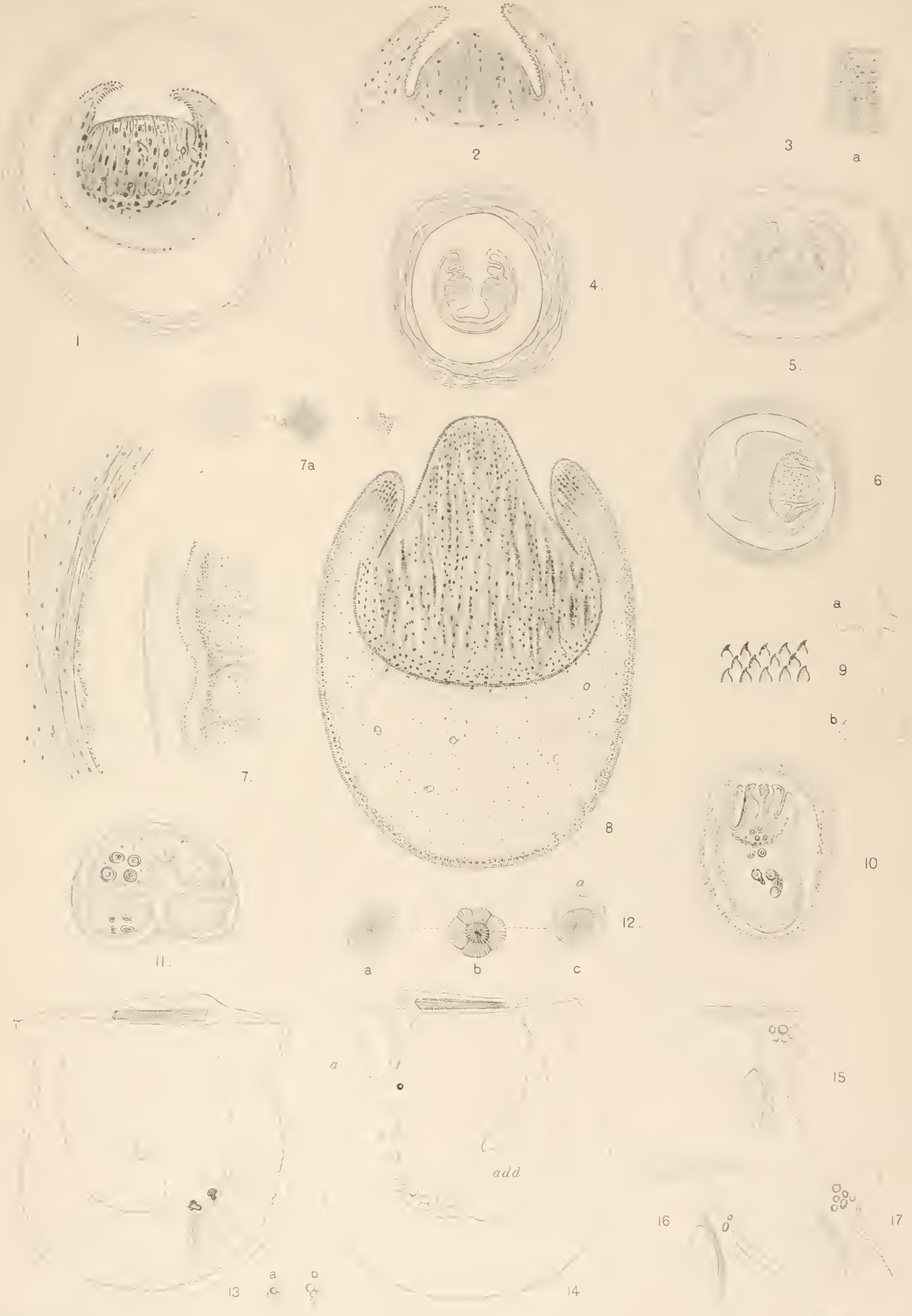
Figs. 13 to 17 are about natural size.

Section of a Tay pearl in the natural condition—magnified. (After M'INTOSH, from 'The Zoologist,' for February, 1904—lent by the courtesy of the Publishers.)



PEARLS AND PEARL CYSTS

CESTODE LARVÆ



CESTODE LARVÆ AND PEARLS

REPORT

ON THE

CESTODE AND NEMATODE PARASITES

FROM THE

MARINE FISHES OF CEYLON.

BY

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[With SIX PLATES.]

In this Report the Cestodes and Nematodes collected from fishes taken off the Coast of Ceylon, and especially in the Gulf of Manaar, mainly in the first half of 1905, are described alphabetically under their several hosts, which in their turn again are arranged alphabetically. The Trematodes follow in a separate article which Dr. Lühe, of the University of Königsberg, has been good enough to write.

Owing to the necessity of bringing to a conclusion this "Report to the Government of Ceylon," the time allowed for the investigation of the large number of Cestodes in the collection was very limited, and it has not, except in very few cases, been found possible to "sectionize" the tape-worms. The following descriptions are based on observations made on the living animals and on those that had been killed, stained, and mounted. Many genera and species were represented by but two or three specimens, and in some cases even one was all that was available for study. We are greatly indebted to Mr. E. Wilson, of Mill Lane, Cambridge, for the care he has taken in drawing many of the figures which illustrate this Paper.

I. CESTODA.

We shall print the names of the fish-hosts in small capitals in the centre of the line, the names of the Cestode parasites will be in Clarendon type, the genera in the centre of the line, and the species at the left-hand margin.

AETOBATIS NARINARI (EUPHRASEN).

The Tamil name is "Pua tirikkai." Occasionally it is also termed "Kuruvi tirikkai," the "bird-ray"; but this latter is a somewhat general term applied to several of the bird-like rays and analogous to our use of the term "eagle-ray." *Pua tirikkai* is the true distinctive Tamil term. In Sinhalese it is "Pulli-maduwa." Very characteristic features of this fish are the *blue-black* tint of the flesh, and the manner in which the inner surface of the stomach is raised into a multitude of stout fleshy papillæ.

The specimens dissected were :—

A. A small individual from Puttalam Lake, opposite Kalpitiya. Width of disc, $14\frac{1}{2}$ inches; $6\frac{3}{4}$ inches between mouth and anus; length of tail, 32 inches. December 30, 1904.

B. A larger one from the open sea off Dutch Bay Spit. January 2, 1905.

C. A third individual from same locality as B. January 6, 1905. Dimensions :—Width of disc, $27\frac{1}{2}$ inches; length of disc, 27 inches; length of tail, 34 inches. From the root of the tail to the root of the tail spine was 11 inches.

Food:—Specimen A. The stomach contents consisted entirely of the remains of Lamellibranch shells and visceral masses. There were fully two hundred recognizable pedal fragments, belonging apparently to a small *Mactra* and allied forms.

B had been feeding principally upon the feet and siphons of Gastropods. A single small Hermit-crab (*Eupagurus* sp.) was also present. The stomach of C was empty.

Cephalobothrium, n. gen.

A large, median, circular sucker takes up most of the head; it is controlled by longitudinal muscles. Four small spherical suckers are placed equidistant from each other in the rim of the circular sucker. The proglottides are wider than broad, with the exception of the last six or seven. The reproductive pores are lateral and very irregularly alternate.

Cephalobothrium aetobatidis, n. sp.—Plate I., figs. 1, 2, 3 and 4.

This curious Cestode was drawn from life by Mr. HORNELL in Ceylon, the enormous terminal sucker being, in that state, much more conspicuous than in the preserved

material. This sucker is round, with thickened edges, and from its underside run longitudinal bands of muscles which apparently control it.

The whole head is rounded, shaped like a turban, and bears four minute spherical suckers on the edge of the great median terminal sucker. There is no neck. The proglottides begin immediately after the sucker.

The whole length of the single worm we had at our disposal is 10 millims., but the posterior proglottides seemed ripe; the breadth of the head and of the posterior proglottides is 0·5 millim., the rest of the body is very fine and slender. The proglottides remain broader than they are long until within the last six; here they become square, and the last of all is almost twice as long as it is broad. The posterior angles of each proglottis overlap the anterior rim of the succeeding one, but not to a very pronounced degree. The reproductive openings are very irregularly alternate and lateral.

Habitat:—The spiral valve of *Aetobatis narinari*, taken off Dutch Bay, Ceylon. The specimens came from the fish described above as B.

Hornellobothrium, n. gen.

Very minute, 2 millims. in length. Head with rostellum and four suckers. No neck, but the body behind the head expands into a flattened region, something like the hood of a cobra; some twenty segments make this; the breadth then contracts and the proglottides become cylindrical. Cuticle finely striated. Reproductive pores alternate, slightly irregular.

Hornellobothrium cobraformis, n. sp.—Plate I., figs. 5 to 10.

Great numbers of this curious and very minute species were found in the spiral intestine of *Aetobatis narinari*; five of these were sent to England. They are so small as not to be much more than visible to the naked eye, for although they are—or at any rate the two larger are—2 millims. in length, they are of an extreme tenuity in breadth, looking like little bits of very fine white silk.

When alive, these Cestodes have a head with knob-like rostellum, on a constricted stalk; this emerges from a broader squarish base, whose angles bear four deep suckers. The whole is capable of considerable expansion and contraction; and constitutes the head. There is no neck, the proglottides beginning immediately after the head. The first twenty proglottides widen out to form a broad flattened part of the body, in outline like the inflated hood of a cobra. These proglottides are all many times as broad as they are long, and the ratio of these diameters is greatest about the tenth or eleventh segment. About the twenty-first or twenty-second segment the proglottides become, perhaps, twice as broad as long and by the twenty-fourth they are square; the remaining four or five proglottides are longer than broad, but the longest is never more than twice as long as broad. The posterior edges of the proglottides overhang the succeeding segments, but the extent to which this is done

varies with the state of the contraction or expansion of the body. The cuticle is finely striated. The reproductive pores are alternate, but rather irregularly so, two consecutively left or right sometimes appearing.

Habitat :—*Aetobatis narinari*, in the spiral intestine.

Kystocephalus, n. gen.

Head bladder-like, with four small suckers and a myzorhynchus which is partially covered by a membrane. Proglottides with very salient posterior borders, most of them much broader than long. Lips of reproductive pores, which are irregularly alternate, very prominent.

Kystocephalus translucens, n. sp.—Plate I., figs. 11 and 12.

The two specimens of this worm at our disposal measured, respectively, 10 millims. and 35 millims., yet each appeared to end in ripe proglottides.

The head and the thicker part of the body measured 0·4 millim. in breadth. The head is a curiously bladder-like concern, which takes little stain and bears four very small spherical suckers. There seems to be a myzorhynchus, surrounded and half enclosed in a circular membrane. The membrane, however, has a central circular aperture through which the myzorhynchus protrudes. Immediately behind the head the proglottides appear, and for about one half the body-length they are considerably broader than long; they then become square, and the last five or six are longer than broad. The posterior end of each proglottis widens out like the walls of a funnel and overlaps the anterior end of the succeeding proglottis to a much greater extent than is usual, so as to sometimes cover a third of the hinder proglottis. At least this is the case in one of our specimens; in the other this salient edge was curled back like the brim of a top-hat. The genital orifices are lateral and in the posterior proglottides have very prominent lips; they are irregularly alternate, usually two or three on one side and then three or four on the other.

This form seems to be not far removed from the genera *Tylocephalum* and *Cephalobothrium*, but it is marked off by quite definite features.

Habitat :—*Aetobatis narinari*, in the intestine.

Myzocephalus, n. gen.

"Head" with four slipper-shaped bothridia each divided by a horizontal partition into two areolas. "Head" surrounded and smothered in four most voluminous and crumpled folds like the bothridia of *Anthobothrium*. Proglottides barrel-shaped. Reproductive pores irregularly alternate. Cuticle finely ringed.

Myzocephalus narinari, n. sp.—Plate I., figs. 13, 13*a*, 14, 15, 16*a*, *b*, *c*.

This remarkable form reminds one of an *Anthobothrium* which has enormously developed and crumpled up its bothridia, as in *Phyllobothrium*, and which retains a

myzorhynchus or "head." The largest of our specimens measured 25 millims. in length. The head with its ruff-like bothridia measures 2 millims. across and the posterior ripe proglottides measure 1 millim. transversely. The anterior end consists of a head which bears four slipper-shaped bothridia each divided by a horizontal ridge into two areolas. They are very mobile. In life the head is very contractile and readily alters its shape (figs. 16*a*, *b*, *c*). Its anterior end is rounded. The water vascular canals penetrate the head and anastomose there, branches are also given off into the "ruff." During life the puckered bothridia were continually undergoing changes of form and the whole mass was in constant motion and transformation. The ruff is formed of four immensely crumpled lateral extensions which branch all together and completely hide the head and give the anterior end of the body the appearance of a cauliflower. These four extensions are borne on four stalks which are equally immersed in their voluminous folds. It needs but an extension of the so-called bothridia of *Anthobothrium* to produce this ruff, but if the extensions are morphologically bothridia, then in this worm we have a double set of bothridia, one in the head, the other forming the ruff. The excretory tubes on each side extend to the end of the myzorhynchus, and then double back.

There is no neck, the transverse divisions beginning immediately after the insertions of the ruff. The line between the proglottides is straight, and except faintly at the anterior end of the body there is no trace of overlapping. The cuticle is finely ringed. The proglottides are barrel-shaped, arching out at each side. The first differentiation which arises in the growing proglottides is the appearance of the scattered testes, and almost at the same time the primordium of the uterus and genital ducts arise. The uterus even in our ripest specimens remains unbranched. The complex of the ovary and shell gland lies posteriorly. The openings of the genital duct are irregularly alternate, perhaps 4 on the right side, 1 on the left; 5 on the right, 3 on the left, and so on.

Habitat:—The spiral intestine of *Aetobatis narinari* taken off Dutch Bay, Ceylon. These Cestodes came from the specimen B mentioned on page 44.

Myzophyllobothrium, n. gen.

Long worms, some 80 millims. in extent. Head with myzorhynchus with four suckers, four bothridia, sessile, with smooth edges and a thickening (? small sucker) at the apex. No neck. Proglottides never overhanging, with anteriorly straight sides. Red pigment at base of head apparently associated with water vascular system.

Myzophyllobothrium rubrum, n. sp.—Plate I., figs. 17 and 18, and Plate II., figs. 19 to 21.

This curious worm, taken from the intestine of *Aetobatis narinari*, belongs to the order Tetraphyllidea,* CARUS, and to the family Phyllobothriidæ, but it seems to us to

* BRONN'S 'Thierreich.' "Cestoda," by M. BRAUN.

form a new genus which we have called *Myzophyllobothrium.* This form obviously comes near *Phyllobothrium*, but there is no neck and there is a distinct "myzo-rhynchus." It is a much larger form than *Hornellobothrium cobraformis* found in the same specimen.

The worm is a long one for a Selachian parasite, measuring some 8 centims. in our longest specimen, and about 0·4 millim. broad. The head is 1 millim. across. It consists of a terminal myzorhynchus which bears four almost terminal suckers; the whole is very delicate, transparent, mobile and capable when alive of great extension. The myzorhynchus is flanked by four bothria or sessile, leaf-like extensions; these also bear at their apex a small thickening which may represent a sucker. The edges are not crumpled and wrinkled as in *Ph. lactuca*, but are smooth and entire.

There is practically no neck. The proglottides are cut off from one another by perfectly flat partitions at right angles to the surface. The two sides of each proglottis in the anterior half of the body are flat and, as nearly as possible, parallel; behind this the sides become somewhat bowed outward, and thus there is a constriction at the "joint." There is no trace of overlapping of the posterior end of a proglottis over the anterior end of the next succeeding. The centre of the body consists of proglottides, which are about square; the most posterior proglottides may reach a length of three times the breadth.

The testes appear early, and are always accompanied by an L-shaped structure (Plate I., fig. 17*a*), which has a limb passing from the genital aperture to the centre of the proglottis and then another limb running straight back; this probably represents the vas deferens and vagina. The posterior proglottides nearly always have their penes protruding.

When alive, the posterior proglottides readily detached themselves from the worm, and then showed very active movements, crawling about rapidly.

There is a deposit of granular red pigment just behind the head which seems to accompany the excretory canals; at any rate, it runs back along the main longitudinal ducts. It contrasts strongly with the general milk-white colour of the worm.

Habitat:—In the spiral intestine of *Aetobatis narinari*, the individual A from Puttalam Lake.

Tylocephalum trygonis (Shipley and Hornell).*

Tetragonocephalum trygonis, Shipl. and Horn.

This species, which has hitherto been recorded only from the intestine of *Trygon walga*, was found associated with *Tetragonocephalum aetobatidis* and with *Myzocephalus narinari* in the intestine of *Aetobatis narinari*.

* This Report, Part III., p. 51. Since writing this article we have come to the conclusion that the genus we described as *Tetragonocephalum* is identical with Linton's *Tylocephalum*, 'U.S. Commission of Fish and Fisheries,' Commissioner's Report for 1887, Part xv., 1891, p. 805.

Tetrarhynchus aetobatidis, n. sp.—Plate II., figs. 22 to 24.

This species, of which we had but two specimens, measures 12 millims. in length. The head is squarish, with two well-marked suckers on each side and the proboscides emerging at the four angles of the anterior surface. These proboscides are perhaps a little stouter and thicker than usual. They bear the hooks in oblique rows. The hooks at the anterior end of the extended proboscides are strongly curved backward and have a very characteristic haft. There is a prominent projection anteriorly, just where the hook is inserted into the skin. Posteriorly the hooks become more sabre-like.

One characteristic feature of this species is the swelling which takes place at the posterior half of the head, caused by the presence of the stout muscular bulbs of the proboscis. Just before the junction of the proboscis tubes with the proboscis bulbs are two aggregations of red pigment spots. This region is at least twice the diameter of the succeeding body. There is a short neck, or, at least, a region where no divisions are visible. The number of the proglottides in our two specimens hardly surpassed thirty-five, but the posterior ones were not mature. The proglottides are barrel-shaped. The reproductive pores are irregularly alternate, but, as a rule, there are not more than two consecutively on the same side. The cuticle is roughly ringed.

The diagnosis of *Tetrarhynchus aetobatidis* is as follows :—

Head squarish; proboscides rather stout; hooks with tubercle at their base, the anterior strongly recurved, the posterior more sabre-like. The part of the head in which the proboscis bulbs lie is much thicker than the body. Short neck. Proglottides barrel-shaped. Reproductive pores irregularly alternate. Red pigment at posterior end of proboscis tubes.

Habitat :—The intestinal spiral valve of *Aetobatis narinari*. It is also said to occur in *Trygon walga*, and to be common in both Elasmobranchs in Dutch Bay and on the pearl banks.

BALISTES MITIS, Bennett.

The Tamil for this File- or Trigger-fish is "Kilati."

These fishes were abundant on the South-west Cheval Paar pearl banks, Ceylon, on February 5, 1905; eight specimens were caught within a short time. The stomach contents were worms, small Crustaceans, small Lamellibranchs, but no pearl oysters in these particular individuals, due to the absence from this locality of any young pearl oysters at the date in question.

Free in the abdominal cavity of one was a strangely coloured Trematode, $\frac{1}{4}$ inch long. It was light brownish-yellow in ground tint, blotched prettily with chestnut-brown splashes.

From the same individual several encapsuled larvæ of Tetrarhynchids were obtained belonging to several species. Two species are quite distinct from either of the two

described in our first report. The teeth in both more or less graded from large to small in each row, and are not all similar as in those already described.

Tetrarhynchus sp.—Larvæ.

At least two young forms were taken together with some Trematodes from *Balistes mitis*. Some of these belonged to the species *T. balistidis*,* others were in the form of cysts with the head protruded, others again had their heads enveloped in a bladder. A fourth form is shown in Plate II., fig. 25. It is like *T. balistidis*, and consists of a head which has not yet begun to bud off proglottides. The anterior part of the head bearing the lappets is just about as long as the part bearing the proboscis sacs, whilst the median portion traversed by the proboscis sheaths is two to three times as long as either. The proboscis teeth are graded in each row from long narrow, sabre-like outlines to short beaked forms (Plate II., fig. 26). From the account drawn up at the time of capture from the living material this form had evidently only just escaped from a cyst of the *T. erinaceus* type.

A very different form of *Tetrarhynchus* larva was also taken from the tissues of *Balistes mitis*, and is shown in fig. 27. Here there is no enveloping bladder, but the Tetrarhynchid head is attached and protrudes from a vesicle which shows signs of an excretory pore posteriorly. This larva is evidently one of VAULLEGEARD'S first division, of which *T. lingualis* is the type. The larva differs from the form we described, under the name of *Tetrarhynchus balistidis*, in Part II. of these reports inasmuch as there is the large vesicle present. The whole length of the larva and head is just under a millimetre. The teeth, as drawn from living specimens, are shown in Plate II., fig. 27*a*. The wall of the vesicle, seen under a high power, seems to contain a large number of globules, possibly calcareous bodies.

CARCHARIAS GANGETICUS, MÜLL. and HENLE.

A specimen, measuring 5 feet 6 inches in length and 32 inches in breadth behind the pectoral fins, was taken on January 3, 1905, in Dutch Bay, Ceylon. The contents of its stomach were many fish-bones, but in the small intestine a number of Tetrarhynchids which fall into two species were found. No Entozoa were found in the spiral valve, usually a favourite haunt of parasites.

Tetrarhynchus gangeticus, n. sp.—Plate II., figs. 28 and 28*a*.

Two forms of *Tetrarhynchus*† were taken in the intestine of *Carcharias gangeticus*, one with a stout smooth head, which we have named *T. gangeticus*, and the other smaller with a rumpled head. The former was found in very few numbers, and the three specimens sent to England were short, 10 millims. long, but at least 2 millims.

* See this work, Part II., p. 89.

† Neither agree in many particulars with the *T. carchariæ rondeletii* of WAGENER, *v.* 'Acta Ac. German.,' xxiv., supplement, 1854.

broad, and the head is 3 millims. at least in width. *T. gangeticus* has a smooth, white head, two very clearly defined and large lappets, somewhat heart-shaped, the apex pointing forward and the four proboscides issuing near the two apices, two on each side (Plate II., fig. 28). The proboscides are stout and bear teeth of many sizes. On the concave side of the extruded proboscis are large, strongly recurved teeth; these are flanked by teeth of lesser size, and they gradually diminish until upon the convex side there are a multitude of fine toothlets. Although it is rather masked, these teeth are really arranged in very obliquely placed rings.

The edges of the lappets are outstanding and sharply separated from the head, and they have clear-cut edges.

The proboscis-tubes leading to the proboscis-bulbs are not spirally twisted so much as bent in and out. The head narrows posteriorly, anteriorly it is 2 millims. in width, and the whole is 3 millims. in length.

There is no neck, the proglottides appear immediately after the head. As there were but three specimens, one only was mounted, and this, which is drawn on Plate II., fig. 28, shows only just the anterior five or so proglottides.

The diagnosis of *Tetrarhynchus gangeticus* is as follows:—

Short (10 millims.), stout (2 millims., and head 3 millims. in breadth) forms. Head with two very clearly cut lappets standing out from general surface. Proboscides stout, with large hooks on one side, diminishing regularly to small hooks on the other. Hooks arranged in oblique rings. Proboscis-tubes bent in and out.

Habitat:—Small intestine of *Carcharias gangeticus*.

Tetrarhynchus perideræus, n. sp.—Plate II., figs. 29, 30, 30*a*, 31*a*, *b*, *c*.

This species was present in large numbers in the small intestine of *Carcharias gangeticus*. The head, and a peculiar extension of the head in this species, is a well-marked shade of dark grey, which contrasts vividly with the matt-white of the rest of the body. Even in the stained and mounted specimens, peculiar coloured granules can be recognized, which doubtless give rise to this colour in the live animals.

This is a big species, some specimens attaining a length of 70 millims., possibly more, as the bottle in which they travelled was full of fragments. The width varies, but is never great, and even the head never exceeds about 1·3 millims. The head bears two lappets, but they are so divided in the centre as to appear like four. They are very compressed into the head and do not stand out. They appear rather puckered at their edges. The proboscides are slender, and bear oblique rows of very minute teeth, all of uniform size (Plate II., fig. 30*a*). The proboscis-tubes and proboscis-sheath are alike short. The head is produced backwards into a very characteristic collar which overhangs and embraces the anterior part of the body. This is a very marked feature (Plate II., fig. 30).

There is a fairly long neck, the first trace of segmentation occurring some way behind the posterior limit of the collar. The proglottides have straight sides, and

except at the posterior end there is no sign of the cuticle being indented between them. One peculiarity is that the body, usually about the middle of its length, is thrown into coils and twists of a very characteristic form. In the anterior proglottides one sees a central stained part, possibly the uterus; posteriorly, however, the scattered testes are visible, and the vas deferens and penis, represented sometimes by a clear area, runs from about the centre of the anterior border of each proglottis to the middle of either side, right or left, irregularly alternating.

The diagnosis of *Tetrarhynchus perideræus* may run :—

Head with well-marked backwardly directed collar which, together with the head, is dark grey; the body is white. Some 70 millims. long. The two lappets are almost split into four and lie adpressed and crumpled in the head. Teeth all of the same size. Neck rather long. No constrictions between the proglottides except posteriorly. Penis runs from centre of anterior edge of proglottis to the centre of either side.

Habitat :—The small intestine of *Carcharias gangeticus.*

CARCHARIAS MELANOPTERUS, Quoy and Gaimard.

This fish is in Sinhalese called "Kunda mora." The specimen we examined contained in its stomach a large specimen of the genus *Caranx*. It was caught at Dutch Bay Spit on January 5, 1905, and contained in its intestine the three species of Cestodes described immediately below.

Phyllobothrium minutum, n. sp.—Plate III., figs. 32 and 33.

One or two examples of two forms of *Phyllobothrium* were found in the intestine of *Carcharias melanopterus.* They are a great deal smaller than, for instance, *Phyllobothrium thridax* described by Zschokke, but their head and general structure coincides with that of the genus.

Phyllobothrium minutum measures 8 millims. in length and at the widest 0·3 millim. in width. The neck is very fine and whip-like; it terminates in a small head. The head bears four bothridia with on each an accessory sucker or areola (Plate III., fig. 33). The edges of the bothridia are crumpled, at least slightly so. The round areola was near the centre of each bothridium. The neck is long .and very transparent. The number of proglottides some 80 to 100; each slightly overlaps the one behind it. The central proglottides are still a little broader than they are long, but the posterior are at least one and a half times longer than broad (Plate III., fig. 32).

The reproductive pores are lateral and all on the same side.

The diagnosis of *Phyllobothrium minutum* may run :—

Length 8 millims., greatest breadth 0·03 millim. Head with four sessile bothridia, each bearing a single, large, round areola near the centre. Proglottides 80 to 100, neck fine and transparent.

Habitat :—*Carcharias melanopterus*, in the intestine.

Phyllobothrium pammicrum, n. sp.—Plate III., figs. 34 and 35.

This is the second small *Phyllobothrium* found in the intestine of *Carcharias melanopterus.*

Two specimens which were mounted measured 13 millims. and 11 millims. respectively. The greatest width was 0·5 millim. The head and neck are very transparent. The head carries four sessile, rather crumpled bothridia, in which there are no areolas. The edges of the bothridia are decidedly crumpled. Many muscles run down from the head through the neck, which is long (Plate III., fig. 35).

The strobilization is peculiar. There is no sign of the gradual differentiation of the proglottis first as a narrow band, which broadens as it passes backward, but the most anterior segment is almost as large as those which succeed it—perhaps one ought to say, those which precede it (Plate III., fig. 34). The proglottides have straight parallel sides and straight parallel ends, and their hinder edges do not overhang the front edges of the next behind. The reproductive pores are lateral and confined to one side. The posterior segments are three times as long as they are broad, sometimes even a little longer.

The diagnosis of *Phyllobothrium pammicrum* may run :—

Length 11 millims. to 13 millims. Greatest breadth 0·5 millim. Head with four sessile bothridia crumpled, with no areola. Neck long. Proglottides when they first appear are almost of full size, with straight sides and ends, and no overlapping. Reproductive pores lateral and on one side only.

Habitat :—In the intestine of *Carcharias melanopterus.*

Tetrarhynchus carcharidis, n. sp.—Plate III., figs. 36 and 37.

A minute form of *Tetrarhynchus* was found in the intestine of a *Carcharias melanopterus* taken in Dutch Bay on January 5, 1905. The length usually 9 millims. The anterior end of the body is extremely thin and whip-like; the body, however, thickens posteriorly until the two last proglottides are 0·5 millim. in thickness. These proglottides are very long, 1·5 millims. and 2 millims. respectively.

The head is minute, and in stained specimens takes little stain. The two lappets are smooth at their edges, not wrinkled, and with no indentation or sign of division into two. The proboscides are very fine, and bear a number of spines, not hooks. These spines are thicker at the base than at their free end; they all point backwards. They are very minute, and seem to be arranged in slightly oblique rings. The proboscis-tubes are very closely coiled, and end in the four muscular bulbs, which hardly occupy one fifth of the total head length. The whole head seems to be dusted through with granules (Plate III., fig. 37).

There is no neck. The narrow, band-like proglottides appear immediately behind the head, and they and even the hinder proglottides are separated by quite clear transparent divisions. There are only some eighteen or nineteen proglottides, and we

were unable to make out the anatomy of these, as it seemed the material was not very well preserved.

The diagnosis of *Tetrarhynchus carcharidis* is as follows :—

Minute, some 9 millims. Anterior end of body very fine and whip-like. Head small, proboscides very fine, with backwardly directed spines, not hooks; lappets with simple edges, not wrinkled; proboscis-tubes very coiled, proboscis-bulb one-fifth the length of head. Eighteen or nineteen proglottides, separated by clear, transparent partitions, at first very narrow from front to back. The last two attain a length of 1·5 millims. and of 2 millims., and a width of 0·5 millim.

Habitat :—*Carcharias melanopterus*, in the intestine.

CHILOSCYLLIUM INDICUM (GMEL.).

This fish is termed "Kurakan sūra" in Tamil.

A female, sexually mature, and having an egg capsule in each uterus, was caught on the North Modragam Paar, Ceylon pearl banks, on February 3, 1905. The stomach contents consisted of small fishes.

Carpobothrium, n. gen.

A minute form, belonging to the Phyllobothriidæ. The head consists of four stalked bothridia, each ending in a circular, flat area, from which project two processes, which are opposed to one another. One of these is obcordate in outline. The body is coiled, with little or no neck, the cuticle very crinkled.

Carpobothrium chiloscyllii, n. sp.—Plate III., figs. 38 and 39.

These peculiar and minute little tape-worms were taken from the intestine of a *Chiloscyllium indicum*, the common "dog-fish" of the Indian Ocean, on the North Modragam Paar, Ceylon. They are short and in all cases coiled forms, the whole animal being twisted up into a bunch not more than 1 millim. by 0·5 millim.

The head is remarkable for four long arms which end in four remarkable suckers. The arms stand out at right angles to one another and to the neck; they consist of a stalk terminating in a very peculiar bothrium. The stalk is capable of considerable extension. In a sketch made from a living specimen each of the four stalks are extended till they attain a length of about one-sixth the total body length and have parallel sides. In the preserved specimens the stalk is contracted and conical. Each stalk ends in a circular, slightly concave area, from the centre of which emerge two processes, slightly flattened and opposed to one another. The process which is nearer to the centre of the head is obcordate like a violet leaf, the second process is rounded. Around the base of these is a ring of muscle fibres, which is, however, broken into two halves, as is shown in Plate III., fig. 39. The bothridia are very mobile, and take up different outlines in different specimens.

There is practically no neck; the sharp, unstained clear lines which represent the division between one proglottis and the next begin close behind the head. At first the proglottides are much broader than long, but they very soon become square and then much longer than broad, till at the hind end the length is six or seven times the breadth. There are only seventeen or eighteen proglottides in all. Unfortunately the details of the inner anatomy refused to reveal themselves by staining. Two peculiarities of the body are the way it is coiled up, as is characteristically shown in Plate III., fig. 38, and the rapid rate at which the proboscides lengthen.

Habitat:—The intestine of *Chiloscyllium indicum.*

CHIROCENTRUS DORAB (Forsk.).

This fish, the only representative of the family to which it belongs, inhabits the Indian Ocean and the seas of China and Japan. It is known as "Vālai" or "Wālai" in Tamil, and as "Katuwalla," Sinhalese, literally a "bunch of thorns," a reference to the multitude of needle-like bones that are present in this fish. Our specimen was caught at Kalpitiya, Ceylon, on December 29, 1904, and contained Trematodes in the anterior end of the intestine and Tetrarhynchid cysts.

Tetrarhynchus, sp.—Cysts (α).—Plate III., figs. 40, 40*a* and 41.

A number of small cysts containing *Tetrarhynchus* heads were found in the body of *Chirocentrus dorab*, taken at Kalpitiya. They were all taken from the peritoneum.

The cysts are 8 to 12 millims. long, and consist of an oval head 0·7 millim. in breadth and 1 millim. in length, and a long flaccid tail about 0·3 millim. to 0·4 millim. in width. The larval *Tetrarhynchus* lies entirely in the head (Plate III., figs. 40 and 41). It consists of a head and a small unsegmented body piece. The head shows well the four proboscides with their teeth, the proboscis-tubes and the proboscis-bulbs.

The whole cyst is contained in an outer sheath, which is probably a portion of the host. The Cestode part resembles a cysticercus which has been drawn out into a long tail. The head of the *Tetrarhynchus* is invaginated into the sac, but the outer wall of the invaginated portion seems to fuse with the inner wall (which is, of course, the actual outer wall of the *Tetrarhynchus* head) near, but not quite at the posterior end.

The whole cavity of the cyst, into which the end of the larva sticks, is full of cells sparsely distributed with apparently many vacuoles containing fluid between the cells. The nuclei are large. The same tissue occupies the lumen of the tail.

Judging from the number collected, these cysts must have been common in the fish. Unfortunately, it was impossible to make out any detail of the teeth in the retracted proboscis, and as the head alone was present, all characteristics of the proglottides were equally hidden. Hence nothing could be done to determine the species.

Tetrarhynchus, sp.—Cysts (β).

Two different kinds of cysts were found in a second specimen of *Chirocentrus dorab* taken at Marichchukaddi. One closely resembled *T. balistidis*, the other was enclosed in a cyst of peculiar form. The head of the animal lay in a little golden cyst, 2 millims. long by 1 millim. broad, which is continued posteriorly into a long, thin tail some 8 millims. or 9 millims. long.

CYBIUM GUTTATUM, Cuv. and Val.

This fish, one of the "Mackerels" or Scombridæ, harboured two kinds of Tetrarhynchid cysts. The "Seer," as it is called, is one of the most esteemed food-fishes of the Europeans in Ceylon.

Tetrarhynchus, sp.—Cysts.—Plate III., figs. 42 and 43.

A number of Tetrarhynchid larvæ were taken from the peritoneum of a *Cybium guttatum* captured off Trincomalee. Like those described in Part II. of this work as *T. balistidis*, they exist in two stages, one in a cyst, the other without a cyst. Whether one of these is, as we assumed in our description of *T. balistidis*, an older form of the other, or whether they represent separate species, is uncertain. That they are both larval is shown by the entire absence of any proglottides. The form without the cyst is somewhat egg-shaped, 4 millims. long and at its widest 2 millims. broad (Plate III., fig. 42). The most interesting feature in it is that the tail or posterior end is ensheathed in a circular fold like a petticoat, and from it runs up a number of ribs or ridges which fade out in the head. The teeth on the proboscides are large and stout and comparatively sparse (Plate III., fig. 42).

The other larvæ, which on the whole we are inclined to regard as a different species, are enclosed in a voluminous cyst which may attain a length of some 14 millims. and a breadth of 2·5 millims. They were dissected out from the peritoneum of *C. guttatum*. The larval head is very much smaller than that just described; it is invaginated, and the walls of the cavity in which it lies meet and all but fuse (Plate III., fig. 43). They are then continued backward as the wall of the cyst, which is constricted here and there. Posteriorly the exit of the excretory system is visible. The cyst is enclosed in a secondary cyst pathologically formed from the tissues of the host in which it lives. They evidently belong to the second group into which Vaullegeard divides the Tetrarhynchidæ, the type of which is *T. erinaceus*.

In another specimen of *Cybium guttatum*, taken at Marichchukaddi, there were several cysts very like those described above, and two very different species of Trematode.

DIAGRAMMA, sp.

Tetrarhynchus, sp.—Cysts.—Plate III., fig. 44.

A number of Tetrarhynchid cysts were taken from an undetermined species of *Diagramma*, a sea-perch common in the hotter parts of the Indian and the Pacific

Oceans. They belonged to the form enclosed in a bladder, *e.g.*, *T. erinaceus*. They are small, measuring 2 millims. by 1 millim., and the head is extremely minute and rather coiled. We figure the cyst on Plate III., fig. 44.

LUTJANUS ANNULARIS, Bloch and Schn.

Tetrarhynchus, sp.—Cysts.

A few small cysts of *Tetrarhynchus* were found in the tissues of this fish, one of the Serranidæ, but little could be made out of them. The same tissue contains a number of oval, brown, glistening, granular-looking bodies, which may have been a species of *Sarcocystis*.

MYLIOBATIS MACULATA, Gray and Hardw.

This common Eagle-ray is known in Tamil as "Panjadi" or "Panchadi tirikkai," also "Neduvali tirrikai," or the long-tailed Ray, and in Sinhalese as "Panjadiya maduwa."

The food of this fish consists of Crustaceans (hermit crabs) and the feet of Molluscs, chiefly *Turbinella* and *Murex*, also *Strombus*, whose opercula were found in the stomach.

Anthobothrium crispum, n. sp.—Plate III., figs. 45 and 46.

A few specimens of this species were taken from the intestine of *Myliobatis maculata*. For Elasmobranch Cestodes they are large tapeworms, reaching a length of 8 centims. or 9 centims. The head is 3·5 millims. in diameter. It is produced into bothridia whose edges are much crumpled, frilled, fringed and subdivided. In some cases the subdivision extends a good way towards the pedicel, and gives the head the appearance of consisting of six or eight bothridia. The pedicels are very short and the bothridia seem to be almost sessile. No myzorhynchus was visible.

The neck is very long, and even quite posteriorly the proglottides show very little demarcation. There is no indentation of any sort. The line which separates one proglottis from its neighbour is usually clear and sharp in the centre, but it hardly reaches the sides of the tapeworm. These latter are quite smooth, and, except that the body slightly increases in thickness, they would be quite parallel. The neck is about 0·7 millim. in width, the posterior part of the body 1 millim. in width.

The specimens did not stain well, and all that could be made out was an L-shaped structure, of which one arm represents the reproductive ducts running to the pore and the other arm the uterus. The reproductive pores are irregularly alternate.

This form is much more slender than the *A. rugosum* of *Trygon walga* and the bothridia are less stalked.

The diagnosis of *Anthobothrium crispum* is as follows:—

Length, 8 or 9 centims. Head with four fringed bothridia, somewhat sub-divided

and with practically no pedicels. Neck long. Division between proglottides feebly marked, no constriction or overlapping, and the dividing line does not reach the edges. Sides smooth and almost parallel. Reproductive pores irregularly alternate.

Habitat :—Intestine of *Myliobatis maculata.*

Diagonobothrium, n. gen.

Head 2·3 millims. in length, about 1 millim. in breadth. There is a large terminal muscular sucker and two ear-like bothridia which run down right and left of the head. One edge of each of these bothridia runs forward obliquely, and loses itself in the crinkled membrane which surrounds the terminal sucker. There is only one edge on each side thus prolonged, and the two prolongations cross one another at about a right angle. The head is thus asymmetrical. The neck is long and shows hardly any structure.

Diagonobothrium asymmetrum, n. sp.—Plate III., fig. 47.

A single specimen of a curious tapeworm was found, with *Anthobothrium crispum*, in the intestine of *Myliobatis maculata* taken in Dutch Bay. Unfortunately the head and neck, which showed no strobilization and no structure, were alone taken. The head consists of a very large and muscular sucker, centrally placed and terminal. The sucker is surrounded by a rather wrinkled membrane. The head is 2·3 millims. long and anteriorly 1·2 millims. wider; its average width is about 1 millim.

Each side of the head are two somewhat ear-shaped lateral, hollow bothridia, and the peculiar feature of the head is that one edge of the bothridia is continued up on to the membrane which surrounds the terminal sucker in an oblique manner (Plate III., fig. 47). The other edge of each bothridia is not so prolonged. Thus it comes about that these prolonged edges cross one another, one being on one side, and the other being on the other side of the head. Hence the head is not symmetrical about any plane, and it would be impossible to cut it into two symmetrical "looking-glass" halves. This feature is very unusual in a Cestode, and one could not put from one's mind that it might be an abnormality, especially as only one specimen was taken, and that without any proglottides.

The neck was long and showed little structure, and it was broken across before it began to segment.

Habitat :—The intestine of *Myliobatis maculata.*

Rhoptrobothrium, n. gen.

Minute forms. Head with four bothridia surrounding a myzorhynchus which carries four suckers. Bothridia stalked and leaf-like, with the terminal end cut off and forming an areola. Head extends behind the insertions of the stalk of the bothridia and is followed by a neck,

Rhoptrobothrium myliobatidis, n. sp.—Plate III., fig. 48.

Of this minute Cestode, one only was available, and that included little more than the head, and was in a poor state of preservation, showing very little histological detail. The length of the worm, which was obviously imperfect, was 1·8 millims., and the arms of the head when stretched measured 1 millim. from tip to tip.

The head somewhat resembles the head of *Anthobothrium* or *Echeneibothrium*, that is to say there are four arm-like bothridia, but in *Rhoptrobothrium* the bothridia surround a myzorhynchus which projects forward from their common base. Anteriorly, this ends in a bluntly-pointed knob. It bears at equal distances four rather leaf-like suckers whose edges are curled inwards, and bear half-way along their edge a pair of inwardly directed projections.

The bothridia are stalked and in general outline much resemble an ovate leaf. The stalk arises not opposite the suckers in the myzorhynchus, but opposite the space between each pair of neighbouring suckers. The tip or terminal fifth of each bothridium is cut off from the rest by a ridge, and forms a shallow sucker or areola. The edges of the remaining four-fifths are incurved.

Behind the insertion of these bothridia there is a region which may be called the head; this does not stain deeply. It contracts and is succeeded by a neck which stains well. In the single specimen from which this description is taken the rest of the body was absent.

Habitat:—*Myliobatis maculata*, in the spiral intestine.

Tylocephalum dierama, n. sp.—Plate III., figs. 49 and 50.

Along with *Rhoptrobothrium myliobatidis*, a specimen or two of what we take to belong to LINTON's genus *Tylocephalum** were found.

The worms measured between 20 millims. and 35 millims. They were very slender anteriorly, but the posterior proglottides attain a width of 0·5 millim., and the head is about 0·6 millim. in breadth, and is rather longer than broad.

The head consists of an anterior cushion, called a myzorhynchus by LINTON; it is obviously to some extent retractile, and in one of our specimens was slightly "pulled in" in the middle, so that the whole head resembled a cottage loaf. This myzorhynchus is separated from the second part of the head or "bothrial disk," as LINTON has it, by a narrow band, not only by a constriction, but by a band. The "bothrial disk" is spherical and bears four equidistant, simple suckers. There is a short neck. The proglottides are, at the posterior end, not more than twice as long as they are broad. They are flattened. Anteriorly they have salient posterior borders, and these, as they approach the hinder end, become much more conspicuous and overhang an eighth or a sixth of the length of the succeeding proglottis. These funnel-like extensions are very characteristic of this species; they are much less marked in

* 'U.S. Commission of Fish and Fisheries,' Commissioner's Report for 1887, Part xv., 1891, p. 805.

LINTON'S species, *T. pingue.* The last proglottides were equally rounded, and contained a uterus full of ova.

The diagnosis of *Tylocephalum dierama* is as follows :—

Length between 20 millims. and 30 millims. Proglottides with very overhanging posterior borders. The body is flattened.

Habitat : —*Myliobatis maculata*, in the intestine.

RHINOPTERA JAVANICA (MÜLLER and HENLE).

"Of the two species of *Rhinoptera* recorded from Indian waters, *R. javanica* is the fish known as 'Valvadi tirikkai' to Tamil fishermen. From the accounts received of a very closely allied but much larger species which goes by the name of 'Mundeikanni tirikkai,' and which I have not yet seen, I have no doubt that it is the second Indian species of *Rhinoptera*, *R. adspersa* (MÜLLER and HENLE).

"Prior to the present, 'Valvadi tirikkai' has been wrongly identified with *Trygon uarnak.* Mr. H. SULLIVAN THOMAS ("Report on Pearl Fisheries and Chank Fisheries, 1884," Madras, 1884, p. 17) was the first in this error, and until the present his identification has been followed. During my recent stay of several weeks' duration at the fishing station of Dutch Bay I had exceptional opportunity to examine large numbers of Rays, and to learn the native names. Before I had seen any specimen of 'Valvadi,' by enquiry from many different sources I learned that its characteristics were entirely those of a *Rhinoptera.* All the men I cross-examined concerning 'Valvadi' laid stress on the snout being truncate; the skin smooth, without tubercles; and the teeth 'stony.' I showed them sketches of Rays, and in each case they recognised a woodcut of the dental armature of *R. javanica* as identical with that of their 'Valvadi.' They all agreed that this is an oyster-eating species, and SULLIVAN THOMAS' statement that the 'Valvadi' devours pearl oysters is correct, but not his linking of it with the name *Trygon uarnak.*

"Later I had the opportunity to dissect both *R. javanica* and *T. uarnak.* The former agreed in every particular with the description of the oyster-eating 'Valvadi,' whereas the latter had the median region of the dorsum tuberculated, a pointed snout, and a dental apparatus wholly unfitted for devouring oysters of large size. The teeth were comparatively weak and closely approximated in form and arrangement with those of the Crustacean-eating *Trygon walga.* The stomach contents in *T. uarnak* were also Crustaceans, consisting of some scores of the young of a small swimming crab. It goes by the distinctive Tamil name of 'Pullian tirikkai,' *i.e.*, 'spotted Ray.' *T. uarnak* is thus the 'Pullian tirikkai' of the natives.

"Reverting to *R. javanica*, the dissection of three specimens showed the food, as evidenced by the stomach contents, to be exclusively molluscan. They consisted almost wholly of Lamellibranch fragments.*

* The shells from the stomach of this specimen were kindly examined by Mr. E. A. SMITH and Mr. B. B. WOODWARD, of the British Museum, but the fragments were too small to be identified.

"The first individual came from Puttalam Lake, opposite to Kalpitiya.

"Samples from the stomach of the second specimen, taken from the open sea off Dutch Bay, contained nothing but the broken shells and visceral masses of a small thin-shelled *Mactra*, rayed with brown.

"These fishes appear to be gregarious, going about in shoals of great numbers. A reliable fish-curer has informed me that during the Pearl Fishery of 1889 a single net, operated on the adjacent coast, took in a single haul 7,000 individuals. My informant was certain as regards the number stated, as it was he himself who purchased the entire catch. His men, even with additional help, took eight days to complete the cutting up. To keep the fish till ready to cut up, the whole lot was buried in trenches in the sand after being roughly eviscerated. Afterwards the men started at one end and worked methodically through the trenches, one after the other. The same year cholera broke out in the Pearl Fishery Camp in the vicinity (Dutch Bay), and many of the ignorant natives traced the source of the epidemic to this vast heap of fish, which no doubt gave off a strong fishy odour during curing operations."*

Echeneibothrium javanicum, n. sp.—Plate IV., figs. 51, 52, 53, 54, 55, 56.

A collection of seven or eight of these Cestodes was taken from the spiral intestine of a *Rhinoptera javanica* captured off Dutch Bay on January 21, 1905.

The specimens are from 9 millims. to 12 millims. in length and about 0·5 millim. in breadth at the broadest part, but the head, when the bothridia are bent out, is at least 1 millim. across.

The head is followed by a long neck which occupies from about one-third to near one-half of the whole body length. It is in this particular alone that our specimens depart from the diagnosis of the genus given by Braun in Bronn's 'Thierreich.' His description includes the words "Hals kurz oder fehlend." In our specimens the neck is very long, very thin, and most clearly marked off both from the head and from the body (Plate IV., fig. 52).

The head consists of four pedunculated pad-like bothridia, somewhat triangular in shape. Each is traversed by two longitudinal and a number of transverse ridges, separating the surface into a number of areolas (Plate IV., fig. 54). One of these is apical. At the base of each bothridium there are seven areolas, and these are followed by three rows of seven, the central row being ended by the apical areola (Plate IV., fig. 54); the disposition of the areolas is easily understood by a reference to the figures. The bases of the four bothridia fuse together and so form the head, but there is no extension forward of any central portion. There is no myzorhynchus, and the bothridia can be widely divaricated, as fig. 52, drawn from the life, shows. Internally the head contains the nervous system, which consists of a transverse ganglion, runs at each side into the lateral nerve-cord, a plexus of water vascular

* This quotation is from Mr. Hornell's notes.

canals which unravel themselves into two dorsal and two ventral canals which run down the neck (Plate IV., figs. 55 and 56), and a series of muscle-fibres which pass to the base of the bothridia. These muscle-fibres gather themselves up into stout strands which run down the neck, and these, together with the nerve-cords and the lateral pairs of water vascular canals, make up all there is in the neck. The neck and the proglottides are alike striated, the cuticle being very clearly ridged. The striation of the neck is more apparent than that of the body, possibly because the proglottides to some extent break it up. The longitudinal muscles can be seen running down the neck. The proglottides begin at the base of the neck, and their appearance can be judged by Plate IV., fig. 51. In the ripe proglottides the central uterus and the lateral yolk-glands take the form of a coil with three limbs. The coil starts from a point in the posterior middle line, passes forward and turns either to the right or left and returns again posteriorly, then passes across the proglottis and runs forward again. One curious feature is that the turning to the right or left goes in pairs. A pair of proglottides with the turning to the left is followed by a pair with the turning to the right, and so on. These markings, which somewhat resemble the Greek key pattern, give a characteristic appearance to the proglottides. The transverse bar which seems to connect the uterus with either the right or left row of vitellaria is formed of the genital duct and penis. The genital pores are lateral and alternate in pairs, first a pair on the left side, then a pair on the right. The penis is covered with minute spines.

The diagnosis of *Echeneibothrium javanicum* is as follows :—

Length from 9 millims. to 12 millims. Head with no myzorhynchus; the four bothria divided by two longitudinal ridges into three rows of areolas, one of these being terminal; then come three longitudinal rows of seven areolas, and at the base is a transverse row of seven large areolas. A long narrow neck occupies one-third to one-half the body-length. Cuticle very definitely striated.

Habitat :—*Rhinoptera javanica*, in the intestine.

Echinobothrium rhinoptera, n. sp.—Plate IV., figs. 57, 58 and 59.

Along with the *Eniochobothrium gracile* a few specimens of a curious Cestode which we place with the genus *Echinobothrium* were found. The specimens measured about 3 millims. in length, the head slightly over 0·2 millim. As a rule in the genus *Echinobothrium* the head is succeeded by a portion called the "Kopfstiel" by German writers. This bears eight rows of very characteristically shaped spines. In our specimen, however, the head is borne by a long "neck," devoid of spines. This "neck" is 0·3 millim. in length, and in the fresh condition it seemed strobilized, but in the stained and mounted preparations this seems not to be so much a real strobilization as a more or less regular wrinkling of the cuticle. Unfortunately, the number of specimens was so small that we could not settle this point by an appeal to the knife.

The "neck" is followed by an armed region 0·2 millim. long. This has eight longitudinal rows of characteristic *Echinobothrium* teeth, with their basal process, their long fine point and the two side rods at right angles to the rest. The number of teeth in each row was either twelve or thirteen. The armed region was greater in circumference than the neck. Behind it the body soon broke up into proglottides, and of these seven or eight could be recognized as distinct. They increase very rapidly in size, and in our mounted specimen the seventh proglottis is 0·75 millim. in length and 0·2 in breadth, and occupies a bulk of about one half to one third the rest of the body. The only internal organs visible are the testes, arranged much as those of *E. musteli*, as figured by PINTNER,* the cirrus bulb and the cirrus. When the latter was exserted, it was seen to bear very numerous minute recurved hooks (fig. 57). The two points in which this Cestode differs from the other members of the genus, *e.g.*, *E. affine*, *E. typus*, *E. brachysoma* and *E. musteli* are the complete absence of any spines on the head,† and the presence of the naked region or "neck" between the head and the armed region of the body. On the other hand, the shape of the head with its four projecting lappets and its intervening two spoon-like depressions, the armed region, the shape of the teeth, the number of the rows of teeth, the number of the proglottides, the arrangement of the testes, all resemble what we know of the genus, and justify us in including this amongst the species of *Echinobothrium*.

The diagnosis of *Echinobothrium rhinoptera* is as follows:—

No spines on the head. An unarmed region, the "neck," separates the head from the toothed region. Teeth in eight longitudinal rows, about twelve to thirteen in each row.

Habitat:—The intestine of *Rhinoptera javanica*, MÜLL. and HENLE, taken in Dutch Bay, Ceylon, on January 10, 1905.

Eniochobothrium, n. gen.

Small Cestode, ranging from 6 millims. to 12 millims. in length. Head unarmed, with four suckers, rostellum conspicuous. Body divided into several regions, first a narrow neck of three or four segments; secondly, an oval region of eighteen segments, which get broader until about the tenth proglottis and then narrow again —the segments of this region overlap like a many-caped cloak; thirdly, a second very narrow region of eighteen segments, all about the same size; fourthly, the reproductively ripe region of six to eight segments rapidly maturing and becoming very large, the last, and in some cases the last two, being as large as the rest of the body. The reproductive pores are lateral and alternating; the cirrus bulb and cirrus are very large, and the latter has a broad band of chitinous spicules.

* 'Arb. Inst. Wien,' viii., 1888.

† These may have fallen off, but no trace of them was observed in the fresh state.

Eniochobothrium gracile, n. sp.—Plate IV., figs. 60 to 62.

Along with certain specimens of *E. javanicum* from the intestine of the *Rhinoptera javanica* captured off Dutch Bay on January 10, 1905, were some small but very remarkable Cestodes which we have named *Eniochobothrium gracile.* Unfortunately but few specimens of each were taken.

Eniochobothrium gracile measures, according to Mr. Hornell's drawing, natural size, 12 millims., but in the few specimens put into spirit none surpassed 5 millims., and the only one mounted attained a length of 3·5 millims. These specimens, it is true, had all lost their heads, but, as the sketches show, this takes up but a small proportion of the total body length. Possibly they may have shrunk in spirit.

The head is pyramidal in form, the apex pointing forward (Plate IV., fig. 62). This part, which represents the rostrum, is circular in outline, but at the base of the pyramid the circumference becomes quadrangular and bears at each angle a small but conspicuous sucker; behind these the head rapidly narrows towards its insertion into the neck. The rostrum is unarmed.

The drawings made from the fresh specimens show behind the head a short neck of three segments. This is followed by a remarkably expanded portion of the body forming an oval somewhat pointed at both ends (Plate IV., figs. 60 and 62). This expansion consists of some eighteen segments which, beginning behind the neck, gradually increase in width until the ninth or tenth segment and then diminish again until they reach their narrowest at about the eighteenth segment. The posterior edges of these segments are very salient and overlap the succeeding segments, except in the middle line, where there is a break just as there is in front between the right and left sides of an Inverness cape. In fact this portion of the body looks somewhat like the elderly coachmen who figured in the early half and middle of the nineteeth century, encased as they were in innumerable capes, each a little longer than the other, as one penetrated inwards from without.

Behind this oval portion comes another isthmus, consisting again of about eighteen segments, very much narrower than any in the expanded oval region and very much shorter from before backwards. They are perhaps a little wider than the segments of the neck, but they are very small.

We can easily imagine how segments can become larger as they are pushed backward by the intercalation of new segments behind the head, but it is not so easy to see how they shrink. The wide large tenth segment of the oval expanded area must gradually dwindle as it becomes in turn the eleventh, twelfth, thirteenth, and finally the eighteenth. There must be an almost sudden shrinkage as the eighteenth passes into the nineteenth segment, and then the bulk of the segments remain about constant and very minute until the thirty-sixth segment is reached (Plate IV., figs. 60 and 61). After this come some six or eight segments which very rapidly increase in size; so quickly do they grow that each of the last two may equal or even surpass the whole of the rest of the tape-worm

The most conspicuous feature of these large proglottides is the cirrus bulb and the cirrus. The former is conspicuous and median, the latter is in all cases we have examined protruded in the last two proglottides, but most fully in the last. The cirrus is a pleurecbolic introvert, and for one portion, and one portion only, it is covered by a broad band of bristles or minute chitinous teeth or rods. Traces of vitellaria and testes can also be made out. The genital openings are lateral and alternating.

Unfortunately we had only two or three specimens at our disposal, and it was not advisable to cut any of them into sections, so that our knowledge of the minute anatomy is still to seek.

The peculiarities of this Cestode are so marked that it deserves to be recognised as at least a new genus, if not as a representative of a new family. Until we know more of its anatomy it is probably wiser to confine ourselves to the establishment of a new genus, and we suggest the name *Eniochobothrium*, in view of the Cestode's many-caped-coachman-like appearance.

Habitat:—From the intestine of a *Rhinoptera javanica*, MÜLLER and HENLE, taken off Dutch Bay, Ceylon, on January 10, 1905.

Tetrarhynchus unionifactor, SHIPLEY and HORNELL.—Plate IV., figs. 63 and 64.

These specimens were taken from the intestine of *Rhinoptera javanica*, MÜLL. and HENLE, captured in Dutch Bay. They are described as existing in swarms in the stomach, especially at the pyloric end. Very few were found in the spiral intestine. They occurred in all the specimens of *Rhinoptera javanica* captured. The longest was 3 centims., the other two were about half that length; but Mr. HORNELL states that when alive they can extend themselves to 4 or 5 inches. The head and body are stout, averaging a little under a millimetre in diameter; the proboscides are very small and fine, and are invisible to the naked eye. They arise apically, close together at the anterior surface of the head, and are supported by two shallow cephalic suckers or bothridia on each side which meet anteriorly. The neck extends for 1·5 millims. to 2 millims., and contains the four clearly-marked proboscis sheaths and four tubules proceeding from them enclosing the retractor muscles of the proboscides; these are very convoluted. The proglottides are at first broad and shallow, but they soon lengthen, and in the middle of the body they are cylindrical, three times as long as broad and circular in transverse section; their posterior border just overlaps the succeeding segments, but only just. Posteriorly the proglottides lose their shape, become baggy, and develop a purplish-brown colour, and here they are 2 millims. in length and rather over 1 millim. in breadth.

The genital openings are irregularly alternate, there being perhaps two pores on the right side, succeeded by two on the left, then one on the right, and so on.

The anterior proglottides are very shallow, and lie one upon another like a series of

saucers or a pile of developing ephyræ; when they deepen a little, they have one, rarely two, transverse creases in their cuticle, but as they get to be as deep as they are broad, the number of these creases has very much increased, and the posterior end of the body is quite crinkled.

The proboscides are armed with hooks which are spirally arranged; the hooks are not very hooked, and the angle is slight; further, the hooks are all shaped alike and are all about the same size. They are very small.

The two bothridia are comparatively shallow, but during life their edges are obviously very mobile, and they may deepen or become shallower as occasion arises. Their outline is roughly triangular, one angle being anterior. The angles are very rounded, and the deepest part of the bothridium lies in the posterior angles.

We have in these forms, undoubtedly, the mature generation of the larval form we described and named *T. unionifactor* in the tissues of the pearl-forming oyster, *Margaritifera vulgaris*, SCHUM. In the structure of the head, the lappets with bothridia, the arrangement, shape and size of the hooks on the young and the old animals closely resemble one another. There is no doubt that the immature *T. unionifactor* is swallowed by *Rhinoptera javanica* when it eats the oysters, as it undoubtedly does, and that the tapeworm becomes mature in the intestine of the fish, that it lays eggs, and that these, somehow or other, make their way into the pearl oyster. Whether some of these become the little Cestode larvæ around which the pearls are deposited is still largely a matter of conjecture; if they do, they perish in a costly coffin. It is certain, however, that many of the young of *T. unionifactor* escape entombment and grow into the larval forms described in Part II. of these Reports. If we could find quite young larval forms of this *T. unionifactor*, and if on comparison with the forms which make the pearl they appeared to us to be identical, we should have solved the problem of pearl-formation, at any rate in the Ceylon seas. It seems increasingly probable that the pearl-forming Cestode is a *T. unionifactor*, but this has not yet been *proved*.

We described the species from the larva as we had no adults at our disposal; we now add a few more features taken from the adult.

The diagnosis of *Tetrarhynchus unionifactor* is:—

Head and proboscides as in the larva (see Part II. of these Reports, p. 88). Length, 1·5 millims. to 3 millims. Head and body stout. Neck containing the much-coiled proboscis sheaths, and the proboscis bulbs 1·5 millims. to 2 millims. in length. Genital pores irregularly right and left. Anterior proglottides shallow and saucer-like, with projecting edges, but about the middle of the body the proglottides hardly overlap at all, and the right and left sides form a straight line. There is, however, especially anteriorly, a tendency to be crinkled.

The larval form is found in the tissues of the pearl oyster, *Margaritifera vulgaris*, SCHUM., and possibly encysted in the pearls. The adult lives in the stomach of *Rhinoptera javanica*, MÜLLER and HENLE, a great Ray which feeds on oysters.

Tiarabothrium, n. gen.

About 11 millims. to 12 millims. long. Head with four sessile bothridia, each divided into twelve transverse areolas; the bothridia can be raised off the head anteriorly. Two stout muscles enter the head laterally and split up into four muscles on each side, two of which are inserted into each bothridium. Definite neck present, provided with an extensile collar. Proglottides with slightly concave sides, divided from each other by perfectly flat partitions. Genital pores alternate. Penis with numerous spines.

Tiarabothrium javanicum, n. sp.—Plate IV., figs. 65, 66, 67 and 68.

Length of the worm 11 millims. to 12 millims. Breadth of head 1 millim., average breadth of body 0·5 millim.

The head bears four bothridia, each divided by transverse ridges into twelve areolas, which, since each bothridium is oval in shape and rather pointed at each end, are very diverse in size, the anterior and posterior areolas being much smaller than the median. The bothridia are sessile upon the head, and judging from the preserved specimens were closely attached to the head by their whole inner surface. However, the drawing made by one of us of a living specimen shows that they are capable of standing out from the head anteriorly for about one-quarter to one-third of their length. The remainder of the bothridium remains, however, always in continuity with the head, and there is never any question of a stalk. The presence of the bothridia with the areolas gives the head something the appearance of a spherical Chinese lantern (Plate IV., figs. 66 and 67).

Longitudinal sections show that the head is a rather more flattened globe than is our earth. The interior of this globe consists of dense connective tissue, but between this and the inner faces of the bothridia is a layer of very loose tissue, and it is by the play this loose tissue allows that the bothridia can be in the anterior half raised a little away from the surface of the head (Plate IV., figs. 67 and 68).

Two very stout lateral muscles enter the head from the neck. They soon split up into eight separate muscles, of which two are dorsal, two are ventral, and two are right and two are left laterals. There is a lateral and a dorsal behind each of the dorsal bothria, and a lateral and a ventral behind each ventral bothria. As these muscles pass forward the laterals die out, but the two dorsals and the two ventrals are continued forward and break up into a number of small strands, which ultimately disappear in the connective-tissue mass which occupies the centre of the head. The water vascular system lies laterally, but there are at one or two levels cross communications between the right and left vessels, and the vessels on each side are very convoluted and coiled; as they pass down the neck they take up the position of dorsal and ventral vessels on each side of each segment.

The head is followed by a definite neck, and this is clothed by a very turn-down

collar, such as a lower-form Eton boy wears. The free edge of this collar projects backwards for a variable distance. In the living form drawn by one of us the collar is far more extensive than it appears to be in the preserved specimens ; it may have shrunk in the preserving fluids. In the one which was cut longitudinally there is evidence of such shrinking, especially at the base of the head.

The proglottides are at first extremely narrow, but lengthen out until about the centre of the body they are as long as they are broad. Posteriorly they may be three times as long as they are broad, and here they have the somewhat melon-seed outline of the *D. cucumerina.* In front of the last three or four proglottides, each has slightly convex sides, and the posterior edge is slightly broader than the anterior, so that the posterior edge of each proglottis extends a little beyond the anterior edge of the next behind it, but it does not overlap. The junction of two proglottides is always in one plane. The transverse section is almost circular, the dorso-ventral axis being but little shorter than the ventral.

The genital pore is lateral. The penis is armed with innumerable minute recurved spines. The yolk glands are very definitely arranged in a layer external to the other reproductive organs. As they stain deeply they form a conspicuous ring just inside the muscular layer, which is thin. Posteriorly they converge to a spot near which the ovary probably lies. The uterus is thick walled. The testes occupy a large part of the body within the vitellaria, and there is a conspicuous vesicula seminalis, crowded with spermatozoa. There were only two specimens available for study ; one of these was mounted whole, the other was partially sectionized, but in none of the proglottides cut were there eggs in the uterus.

Other specimens of the species *Tiarabothrium javanicum* came from the intestine of the *Trygon walga.* The bothridia were not very distinct, and the number of areolas could not be made out. In one specimen, which was mounted, the breaking up of the longitudinal muscles as they entered the head was very clearly shown. The proglottides are broadest in the middle and narrow towards each end, and the posterior end is no wider than, and does not overlap, the anterior end of the next succeeding proglottis. There is no unsegmented neck, the first proglottis coming immediately behind the head, and the anterior half of the body is broadest at about the region between the eighth and the sixteenth proglottis. The cirrus is armed with spines. The collar is small.

Habitat :—Intestine of *Rhinoptera javanica.*

RHYNCHOBATUS DJEDDENSIS, Forsk.

A ray common throughout the Indian Ocean, from the Red Sea to Sumatra.

Tetrarhynchus rhynchobatidis, n. sp.—Plate IV., figs. 69, 70, and 71.

The Tamil name for *R. djeddensis* is "Pal-ulluvi," the Sinhalese "Kiri-uluwa," or "Uluwa mora." Both "pal" and "kiri" signify milk and refer to the milk-white spots

on the body of the species. Two individuals were dissected; in one the remains of a number of fish, including a young *Pristis* sp., were found, in the other only crustacean fragments. The parasites were few in number and all belonged to one species of *Tetrarhynchus*.

The largest specimen of this *Tetrarhynchus* attained a length of 5 centims.—but since some loose proglottides measured 4 millims. each, probably the full length is greater—and its posterior end a width of 1 millim. The length of the head is 4 millims. The lappets are short and widely separated; anteriorly they occupy 1 millim., and the remaining 4 millims. are equally divided between the part of the head which contains the proboscis tubes and the part which contains the proboscis bulbs. The part of the head which bears the lappets is 1·2 millims. broad, but behind this the head tapers. The colour of the living specimens is an opaque milk-white.

The hooks in the proboscides are arranged in longitudinal rows and also in rings; the latter are almost horizontal, there being only a very slight trace of obliquity as they surround the stem. One peculiarity which we have not noticed in other species is that on each proboscis there is a longitudinal row of hooks, whose points are reversed and look towards the tip of the proboscis and not to the base, as do all the others. The shape of the hooks is shown in fig. 71; some of them are not nearly so hooked as others and pass into sabre-like forms.

Another peculiarity is that the outer muscles of the proboscis bulb are very oblique, very clear, and cross one another at right angles, giving a "Malvolio, cross-gartered" appearance to these structures.

There is a short neck, and then a number of proglottides, five or six times as broad as long, separated one from another by perfectly straight lines and with at first parallel straight sides. They soon, however, begin to lengthen, and at the end of the first quarter they are square. The sides also begin to bow outwards, but the ends are always flat, and there is absolutely no overlapping.

The reproductive pores are lateral and at the juncture of the anterior two-thirds with the posterior third. Their circular lips are prominent and everted. The pores are irregularly alternate; for instance, starting at the last of one specimen, they run as follows:—1 right, 3 left, 2 right, 1 left, 1 right, 2 left, and so on.

The diagnosis of *Tetrarhynchus rhynchobatidis* is:—

Five centims. long, posteriorly 1 millim. broad. Head with small lappets. Milk-white when alive. Proboscides with longitudinal rows of hooks, one row being turned the wrong way, hooks also arranged in nearly horizontal rings. Proboscis bulb chequered by external, obliquely-placed muscles, crossing each other at right angles. Proglottides not overlapping. Genital pores with everted lips, lateral, irregularly alternate, situated at anterior border of last third of the proglottis.

Habitat:—Intestine of *Rhynchobatus djeddensis*.

In another specimen of *Rhynchobatus djeddensis* were a couple of single proglottides

15 millims. in length by about 0·5 millim. in breadth, but in the absence of the head they could not be identified. Specimens of *T. herdmani* described under *Trygon walga* were also taken from this fish.

SPHYRÆNA COMMERSONI, Cuv. and Val.

This is the sole genus in the family Sphyrænidæ. The species are often called "Barracudas"; they are large voracious fishes living in the tropical and sub-tropical seas.

Tetrarhynchus, sp.—Cysts :—

A considerable number of large Tetrarhynchid cysts were taken from the abdominal cavity of a *Sphyræna commersoni.*

The cysts are large forms varying in length between 8 millims. and 30 millims., with a breadth of about 3 millims. They belong to Vaullegeard's *T. erinaceus* series, being enclosed in a vesicle as well as in a cyst, which latter is apparently formed by the tissues of the host. The teeth were very crowded, and the excretory opening was visible, but little else could be made out.

TRYGON KUHLI, Müller and Henle.

This large ray is called in Tamil, "*Kătti tirikkai.*"

Two individuals were dissected; the first captured off Dutch Bay, the second caught on the pearl bank known as South Modragam Paar.

From the stomach contents of these two it would appear that the food consists almost exclusively of small annelids and small crustaceans. In the first named the stomach was distended with a large mass of *Lumbriconereids*, mingled with which were a few thin-shelled small crustaceans. In the second specimen the material was wholly annelidan—*Terebella*, *Lumbriconereis*, *Eunice*, &c.

Phyllobothrium blakei,* n. sp.—Plate V., figs. 72 and 73.

Some half a dozen specimens of this minute worm were taken from a *Trygon kuhli* captured in the pearl banks. Half of these were without heads. They are very delicate, thin, fragile creatures, measuring 10 millims. in length of the body, and at their greatest width some 0·25 millim. to 0·33 millim.

The head measures something over 0·5 millim. It consists of four crumpled bothridia with thickened edges, which are so twisted that they show numerous little bays and rounded recesses which at first sight might easily be taken for small circular suckers. These bothridia spring with practically no stalk from the edge of a hollow which shows some circular markings as if there were here two rings of circular muscles. There is no kind of armature.

The proglottides immediately following the head are broader than the subsequent

* Named in honour of H.E. Sir Henry Blake, K.C.M.G., the present Governor of Ceylon.

ones; they soon, however, narrow, and only very slowly widen again. The sides of the proglottides are straight and almost parallel, and although they project very slightly at their hinder end they do not overlap the succeeding segment. The posterior proglottides are almost three times as long as they are broad, and instead of having square ends they have rounded ones and are swollen in the middle. Their contents seems to be a roomy uterus with numerous large ova. In the stained specimens the central region of each proglottis stains deeply, making a deep line along the centre of the body. The reproductive pores are alternate.

The diagnosis of *Phyllobothrium blakei* is :—

Small delicate forms, 1 centim. long. Head with four frilled bothridia, practically sessile. No neck; the proglottides which come after the head are broader than those that follow. No overlapping at the posterior end of each proglottis. Ends of posterior proglottides rounded. Genital pores alternate.

Habitat :—Intestine of *Trygon kuhli*.

Rhinebothrium ceylonicum, n. sp.—Plate V., figs. 74 and 75.

Although the stalks or pedicels of the bothridia (if indeed they exist at all) must be very short, the specimens about to be described seem to us to belong to LINTON's genus *Rhinebothrium*.* The head bears four fleshy bothridia at the four angles, back to back. Each bothridium is divided into two halves, as in *Rh. flexile*, LINTON, by a longitudinal groove, and each half bears a number of horizontal slit-like areolas placed transversely. The number of these areolas was not exactly made out, but it is somewhere about twenty. The whole recalls a rasp (ῥίνη), after which the creature takes its name. In the preserved specimens, of which only two were taken, the head was rather broader than it was long, its greatest breadth being 4 millims. Judging from the figure taken of the head whilst alive, the length about equalled the breadth. In the living form also the bothridia seem more clearly distinct from one another and from the head; in the preserved form they have all shrunk together.

The length of the body of our longer preserved specimen is 5 centims., but, as in both, the tail is curved up in the lateral plane, and perhaps, if uncoiled, the length would be 5·8 centims. or 6 centims. When alive, it measured 9 inches. The body is stout and wide. Our second specimen—also giving off mature proglottides—was a little more than half this size. In the middle, which is the widest portion, it is 3 millims. broad, and it tapers away slightly both in front and behind. It is 2 millims. thick and is very stiff and firm in the preserved condition.

The neck is short, and the proglottides are at first very narrow from front to back. There seems to be a curious false strobilization whereby five or six segments are grouped together, but this may have been an individual character. The posterior angle of each proglottis was salient and projected slightly over the

* 'United States Commission of Fish and Fisheries,' Report of the Commissioner for 1887, part xv.; p. 768. Washington, 1891.

succeeding proglottis. Only at the hinder end are the proglottides as long as they are broad, and only the last three or four are longer than they are broad. The incurved tail seemed characteristic, at any rate it occurred in both our specimens.

The body was too thick and too opaque for us to make out any details of the internal anatomy.

The diagnosis of *Rhinebothrium ceylonicum* is as follows :—

Head with sessile or almost sessile bothridia, each with two rows of some twenty transverse areolas. Body very stout, 3 millims. in its widest part; very thick, 2 millims.; and varying from 3 centims. to about 5·8 centims. in length. Proglottides with salient posterior edges, mostly much broader than long, but the last few longer than broad and a few squarish. Tail incurved.

Habitat :—*Trygon kuhli*, spiral intestine. According to the collector, the same species occurs both in *Myliobatis maculata* and in *Trygon walga*.

In the same bottle with these two worms was another of a different kind, but whose head was so damaged that it is impossible to accurately diagnose it.

Tylocephalum kuhli, n. sp.—Plate V., figs. 76 and 77.

A single specimen was taken from the intestine of *Trygon kuhli*. It measured 12 millims. in length, and its greatest width, which lies a little before the posterior end, is 0·6 millim. The head consists of two portions, something like a cottage loaf, and in general resembling those of *T. uarnak* and *T. trygonis*. The anterior part or myzorhynchus is, however, somewhat smaller than in those species. The larger and posterior part bears four small spherical suckers. The muscles which enter the head from the body spread out in this portion in a button-like manner. Immediately behind the head is a constriction, and then the proglottides begin.

At first the proglottides are very shallow, with projecting rims like a pile of saucers upside down, then about half-way along the body each proglottis is seen to have a groove in it dividing it into approximately equal halves. If we trace the proglottides still further back, we see that these two halves have very different fates; the anterior becomes the proglottis full of reproductive organs, etc. (Plate V., fig. 76), the posterior becomes the pronounced, everted, and almost recurved, salient edge.

The hindermost proglottis is square, and in no case is the longitudinal diameter greater than the transverse. The last two or three proglottides had the penis protruded, and these were all on the same side.

The diagnosis of *Tylocephalum kuhli* is as follows :—

This form measured 12 millims. in length by 0·6 millim. in width at the widest point. Head separated from body by a sharp constriction. Proglottides at first very shallow, and never longer than broad. About the middle of the body each proglottis is divided into two halves, the posterior does not develop so quickly as the anterior and forms the very marked, recurved, salient, posterior angle.

Habitat :—Intestine of *Trygon kuhli*.

TRYGON SEPHEN (FORSK.).

This fish is known as "Ada tirikkai" in Tamil, and as "Polkolla maduwa" in Sinhalese. A large individual of this species was obtained from the fishermen on Dutch Bay Spit, on January 3, 1905. The breadth of the disc was $47\frac{1}{2}$ inches, and the length from the snout to the butt of the tail was 34 inches.

The stomach itself was empty, but the large intestine was choked with sand, intermixed with which were a large number of partially digested skins of worms, apparently Gephyreans. A few limbs of crabs were also present. It would seem that this *Trygon* feeds principally upon worms, with such small crustaceans as may be associated with them in sand.

Anthemobothrium, n. gen.

Fourteen millims. long when preserved. Head about 1 millim. in diameter, almost spherical, with four small suckers in the hinder half, and fourteen feathered bothridia radiating over the anterior half. Neck narrow and short. Proglottides slightly overlapping their successors. The skin is faintly striped. The uterus in the posterior proglottides occupies almost all the space and is crowded with ova.

Anthemobothrium pulchrum, n. sp.—Plate V., figs. 78, 78*a*, 78*b* and 79.

A single example of this beautiful and remarkable Cestode was found amongst the crowd of *Tetrarhynchus leucomelanus* and *Prosthecobothrium walga* taken from the intestine of a *Trygon sephen* captured in Dutch Bay.

It measures 14 millims. in length when preserved in formaline, and as the posterior segments are crowded with eggs, it is apparently a full grown worm. The head, which is almost spherical and as broad as it is long, measures just under 1 millim. across (Plate V., fig. 79). The neck is very slender and short, and the body gradually, but slowly, broadens until the last segments are about 0·6 millim. broad by 0·9 millim. or 1 millim. long.

The head consists of a basal hemisphere bearing four equidistant, small, rounded suckers. From the distal end of this basal part emerge fourteen radiating bothridia, which are flattened down and look like so many neatly arranged ostrich feathers or frilled petals of a flower.

The neck is narrow and short. The proglottides soon appear, at first much wider than long, but by the middle of the body they are square, and behind are twice as long as they are broad. The genital pore is not clearly visible, but some proglottides seemed to show an aperture on the flat surface near the anterior end. The uterus arises also at this end and is soon evident as a clear coiled tube. The divisions between neighbouring coils soon break down, and in the last proglottis the uterus, crammed with eggs, occupies almost all the space in the segment.

Each segment has a very short lip posteriorly, which slightly overlaps the succeeding one. There is also a curious arrangement, probably of glands, in the skin,

which gives the Cestode a longitudinally striped appearance, darker bands where the glands are present alternating with lighter areas where they are not.

Habitat :—Intestine of *Trygon sephen.*

Prosthecobothrium trygonis, n. sp.—Plate V., figs. 80, 81, 82 (*a* and *b*).

One specimen of this Cestode was taken from the intestine of *Trygon walga* and three from *Trygon sephen.* The longest measured when preserved 120 millims. in length. The worm is very slender and soft and anteriorly very narrow, 0·5 millim. only in breadth, though posteriorly it broadens out to a couple of millimetres.

The head is 1 millim. in width. It is square, something like a cushion which is indented in the centre and along the lateral and dorso-ventral axes. The head is thus divided into four squares of equal area, and each of these squares bears at its external angle anteriorly a large hollow or bothridium, on the anterior edge of which lie the hooks mentioned below. Behind each is a single, round, rather small but quite conspicuous sucker. This sucker is a simple sucker and has no sub-divivions or areolas. On its surface each of the four squares bears two hooks more or less connected at their base ; each hook is forked and consists of two unequal-sized prongs ; of these, that which is next the diagonal lines or lines joining the bases of the suckers is the larger and bears a tubercle at its base. The hooks are dark brown, chitinous-looking structures.

The neck is very long, 2 centims. or 3 centims. at least. It is smooth and traversed by a number of longitudinal muscle bands which are conspicuous through the epidermis. They split up in a symmetrical way in the head.

The proglottides are extremely numerous, they have salient posterior angles. They always remain somewhat broader than they are long, even at the posterior end, except perhaps the very last. This species obviously differs considerably from that described by van Beneden in his "Recherches sur les Vers Cestoïdes"* under the name *Acanthobothrium dujardini*, especially in the relative proportions of the head ; in our worm this is broader than long, in van Beneden's it is longer than broad.

The diagnosis of *Prosthecobothrium trygonis* is :—

Slender Cestode some 12 centims. in length. Head square and divided by depressions into four equal squares. Each of these bears a sucker at its free corner and on the surface a pair of unequally two-pronged hooks. Neck very long. Proglottides very numerous, with very salient edges, never longer than broad, except perhaps the last.

Habitat :—*Trygon walga*, Müll. and Henle, and *Trygon sephen* (Forsk.), in the spiral intestine.

Tetrarhynchus leucomelanus, n. sp.—Plate V., figs. 83, 83*a* and 84.

This large species of *Tetrarhynchus* was found in the intestine of *Trygon sephen.*

* 'Mem. Ac. Belgique,' xxv., 1850, p. 133.

Many specimens were taken which measured in length 5 centims. to 8 centims. The anterior end of the body is slender, scarcely 1 millim. broad, though the lappets are quite that. The body, however, slowly widens, and the posterior third is about 3 millims. wide, and here the proglottides are almost square and in the centre 1·5 millims. thick, though they thin off towards all four edges.

One of the most characteristic features of this species is that, when preserved, it is half white and half black. This is perhaps not strictly accurate, it is about the posterior third that is black, and there is no sharp transition, the pigment appearing about, or soon after, the middle and gradually deepening until it reaches a deep slatey black. The living specimens are described as milky white with a rosy pink smudge, fading away behind, at the base of the proboscis sheaths.

The head is 7 millims. long, at the level of the lappets it is 2 millims. broad, behind this 1·5 millims. and it narrows down to less than 1 millim. at the posterior end. The lappets are but very slightly hollowed, their length is about one fifth the length of the head and they are very symmetrically placed (Plate V., fig. 84). The four proboscides are covered with an immense number of very minute hooks; these are regularly arranged in rings and in numerous longitudinal rows, though the arrangement may be upset near the tip, owing to a bit on one side being more evaginated than on the other. The hooks are all the same size. The proboscis tubules are short and coiled, the arrangement is very symmetrical, the two tubes on each side being coiled parallel to one another. The proboscis sheaths are very long and occupy seven-tenths of the total length. There seemed a certain difficulty in withdrawing the proboscides, at any rate they are seldom completely withdrawn. They are fine and narrow and converge near the posterior end. There is a short neck, and at first the segments are six or seven times as broad as they are long; by the middle of the body they are almost square and the last two or three are longer than broad. A row of well separated but clearly marked longitudinal muscles is conspicuous, especially in the larger segments. The posterior edge of each proglottis is salient and at first a little overlapping, in the posterior proglottides it sticks out like a frill, and forms a quite distinct rim round the posterior end of the proglottis. The generative pores are alternate and rather irregular.

The diagnosis of *Tetrarhynchus leucomelanus* is as follows:—

Five centims. to eight centims. long, with posteriorly thick, stout proglottides, 3 millims. broad. Anterior half or two-thirds of the preserved body white, the remainder slaty black, deepening into a dense black. When alive, milky white, with a pink patch behind the proboscis sheath. Head with two shallow lappets, well defined. Proboscides with an enormous number of very minute teeth, all uniform in size and shape, arranged in rings and longitudinal rows. The proboscis sacs are very long, occupying seven-tenths of the length of the head. There is a short neck, the posterior edge of each proglottis is salient. Generative pores irregularly alternate.

Habitat:—Intestine of *Trygon sephen.*

TRYGON UARNAK (Forsk.).

This fish is called "Pullian tirikkai" in Tamil, which signifies "spotted ray," and well describes its appearance.

One specimen was obtained at Dutch Bay on January 6, 1905. The length of the disc was 28 inches, the breadth 33 inches, and the tail was 56 inches long.

Food.—The stomach contents consisted exclusively of some score of small, swimming crabs.

Tylocephalum uarnak, n. sp.—Plate V., figs. 85 and 86.

A few examples were taken from the intestine of *Trygon uarnak.* The longest measured some 35 millims. The number of segments is, however, small, varying from 30 to 40. The head, which is a little exaggerated in our figure (Plate V., fig. 86), stands out like a button or knob at the end of the fine neck. The body is thickest in the middle, some 0·7 millim. in breadth, the posterior extremely elongated proglottides have a somewhat attenuated look.

The head consists of an anterior lobe, resting on a squarish cushion; the anterior lobe or myzorhynchus seems to be fixed on to an extension borne by the cushion as though on to a peg. This extension seems to be a thickened tissue, into which the longitudinal muscles are inserted. The cushion is square, with suckers at each angle; the anterior lobe is separated from it by a simple contraction, not by a band as in *Tylocephalum pingue.* There is a short neck. The proglottides show very early traces of reproductive organs. The excretory pore is immense, a great round opening, more or less median; posteriorly it loses its firm outline, becomes crinkled, and is pushed a little aside by the development of the uterus. The testes are scattered mostly at the anterior end of each proglottis, and as the uterus develops the testes are pushed towards the periphery and tend to disappear. The uterus is a long sac, constricted in the middle by the reproductive pore like an old-fashioned "ring" purse. The posterior proglottides are extremely long, at least 5 millims. in length, some ten times as long as they are broad. None of the proglottides overlap. Their ends are flat and their sides very nearly straight, or at most slightly bowed.

The diagnosis of *Tylocephalum uarnak* is as follows :—

Length some 35 millims. Greatest breadth in middle region of body. Genital pore very large, round and median. Testes scattered in anterior end of proglottis, pressed outward by the growing uterus. The latter forms an anterior and posterior swollen part united by a thinner portion. Number of segments 30 to 40.

Habitat :—The intestine of *Trygon uarnak.* This species also occurs in *T. walga.*

Tetrarhynchus macroporus, n. sp.—Plate V., figs. 87, 87*a* and 87*b*.

These are fair-sized Tetrarhynchids, averaging about 25 millims. in length and 1 millim. in breadth.

The lateral lappets are small, each divided into two, each half corresponding with

one of the four hooked proboscides. The head is 6 millims. long, and swells out a little behind where the muscular sheaths of the proboscides lie. When alive, there is a patch of pink anterior to these sheaths. Each proboscis bears on its concave side when unrolled a number of strongly recurved teeth, which gradually pass into a much straighter, sabre-like tooth on the convex side (Plate V., fig. 87*b*). The recurved teeth have a marked anterior process something like a sword-guard, where the tooth passes into the haft, which is embedded in the tissue. This is absent in the more sabre-like teeth. The teeth are in rings, which are not obliquely placed.

There is practically no neck, and the number of the proglottides is small, some 30 to 35. Until the last three or four, the sides of the proglottides are parallel, straight at their ends, and with no sign of overlapping. The whole body is marked by a curious longitudinal striation, which is due to the presence of minute pigment spots, and to the fact that these little brownish particles are arranged along certain longitudinal lines; also these pigment spots seem broken up into other areas, which give a mottled appearance to the skin.

The last four or five proglottides are remarkable for the enormous development of the genital pore, which sometimes occupies one quarter to one third of the length of the proglottis. From this gaping cavity a minute penis protrudes. These same four or five proglottides lose their uniform shape, and become very irregular in outline. The pores are in all cases lateral and irregularly alternate.

The diagnosis of *Tetrarhynchus macroporus* is :—

These Cestodes are about 25 millims. in length and 1 millim. in breadth. They have small lappets, turned forward, hooks recurved sabre-like, in straight lines; no oblique rows. Proglottides number about thirty, and the last four or five are distorted by the enormous development of the genital pore.

Habitat :—The intestine of *Trygon uarnak*.

Thysanobothrium, n. gen.

Length 7 centims. ; posterior proglottides being 1·5 millims. to 2 millims. long. Head squarish, with a sheath bearing four minute suckers at the angles; within the sheath a rounded knob, and between the sheath and the knob a ring of some twenty finger-like tentacles stretched forward. Neck long. Genital pores very irregularly alternate.

Thysanobothrium uarnakense, n. sp.—Plate V., figs. 88 to 91.

This remarkable form attains, for a tapeworm parasitic in Elasmobranchs, considerable proportions. Our largest specimen measured 7 centims., and in this animal the posterior proglottides reached a length of 1·5 millims. to 2 millims., and a breadth of 1 millim. The anterior end of the body is, however, very slender, 0·3 millim. to 0·25 millim. in width, but the head, though small, is somewhat wider than this, and attains a breadth of at least 0·5 millim.

The head is squarish, and yet sub-globular, with four minute suckers equidistant from one another at the angles. The suckers are borne on a kind of cup-like external bowl, which surrounds a central portion, and between this cup-like shield and the central portion a number of simple tentacles protrude.

These tentacles are very curious, and, as far as we know, are unique amongst the Cestoda. They are finger-like processes, with no branching, and they hang over the central portion of the head. They seem to be about sixteen to twenty in number, but in the preserved specimens it was impossible to count them accurately.

In the living specimens a number of concretions, apparently of a calcareous nature, occurred at the base of the head, just where it joins the neck. The neck is long, no trace of strobilization appearing for at least a distance of half a centimetre behind the head. The proglottides, when they do appear, are shown by lines in the centre of the body, which do not at first reach the side, so that for a time the sides of the worm are unindented, straight, and almost parallel; then the dividing lines reach the edge and the sides of each proglottis bow out, and by the time the proglottides are about as long as they are broad the body has a somewhat moniliform appearance. The proglottis is symmetrical about a line which passes across it midway between its anterior and posterior edge; there is no overlapping and no trace of it. The posterior proglottides are flask-shaped, and seem to be little more than bags of eggs. The reproductive pores are very irregularly alternate, some six or seven being to the right, then one or two to the left, then seven or eight to the right, and so on. The penis was often protruded.

Habitat:—The intestine of *Trygon uarnak*.

TRYGON WALGA, Müller and Henle.

The Tamil name is "Manal tirikkai," signifying "Sand Ray." This species is perhaps the commonest Ray taken by fishermen in the neighbourhood of the pearl banks. A considerable number were examined, as follows:—

A. Caught on the N.W. Cheval Paar, April 4, 1904.

B, C, D, E, and F. Caught in fishermen's nets in the open sea, January, 1905, off Dutch Bay Spit, N.W. Province, Ceylon.

G. Taken on a line on the North Modragam Paar pearl banks, February 2, 1905.

Food.—As shown by stomach contents, this Ray lives chiefly upon small crustaceans, supplemented frequently by octopods, gephyreans, polychætes, and occasionally thin-shelled small molluscs.

Anthobothrium rugosum, n. sp.—Plate V., fig. 92.

Two specimens of the worm were taken from the intestine of a *Trygon walga*. One measured 65 millims. when preserved, but it had stretched to 12 inches when alive, the other 20 millims. in length. The greatest breadth of the body is about 2 millims.

The head consists of four bothridia, each borne on a short stout stalk. Each bothridium consists of a simple bag-like sucker or depression, the walls of which are rather crinkled and marked with lines, and the edges which surround the opening of the depression are distinctly puckered. All these four bothridia are in both our specimens very much flattened, and all lie in the same flat plain; the head, in fact, looks like a pressed flower. As far as we know, the animals had never been compressed in any way, and this flatness may be natural to the species. Each sucker measures 3 millims. across at its broadest, and the whole head measures 6 millims. from side to side.

It is followed by a neck which extends some 5 millims. or 6 millims., and then the body becomes segmented. The proglottides are always broader than long, and the body is broad throughout, differing in that respect from *A. cornucopia*, VAN BEN.,* whose body "est extraordinairement fin et effilé en avant." Anteriorly there is a curious wrinkling at the edges, and the exact correspondence of this with the limits of the proglottides was not made out. The strands of muscles which run down the body in this region are also very conspicuous and easy to see.

Diagnosis of *Anthobothrium rugosum*:—

This species is distinguished from the *A. cornucopia*, VAN BEN., and the *A. musteli*, VAN BEN., by the wrinkling of the bothridium and the shape of the body, and from the *A. elegantissimum* of LÖNNBERG,† by the absence of a myzorhynchus. Its most striking characteristics are the crumpled suckers, the stout neck, and the longitudinal muscles. Length, when alive, 1 foot.

Habitat:—The intestine of *Trygon walga*.

Echeneibothrium minimum, VAN BENEDEN.‡—Plate V., figs. 93 and 94.

This species is in all probability the *Echeneibothrium minimum* of VAN BENEDEN, although instead of the bothridia fading at their lower end into a stalk like the leaflet of a rose, they are borne on the stalk in a peltate manner. As in *E. variabile*, and unlike *E. gracile*, where there is a terminal areola at each end of the bothridia, the areolas in this species are paired throughout. There is no myzorhynchus. There are thirteen pairs of areolas in each sucker. The bothridium is fringed by a transparent, extensible membranous edge. An excretory tubule runs underneath it. The stalks are very muscular and very mobile.

The worms are slender but long, larger than those which as a rule live in Elasmobranchs, and are intermediate in length between *E. variabile*, with its 100 millims., and *E. minimum*, with its 15 millims. to 17 millims. Our species ranged from about 60 millims. to 30 millims. It attains at the maximum a breadth of 1 millim., and this maximum is not necessarily at the posterior end of the animal.

* 'Mem. Ac. Belgique,' xxv., 1850.

† 'Bih. Svenska Ak.,' xiv., 1888–9.

‡ 'Mem. Soc. Belgique,' xxv., 1850, p. 114.

The body has, in fact, a somewhat lumpy, untidy appearance, and is thrown in irregular wrinkles and sometimes knots. There is no neck, as in *E. gracile*.* The posterior segments are not very long, at most twice or three times as long as wide. The genital pore is lateral.

This species came from the intestine ot *Trygon walga*, the same specimen which contained *T. herdmani*.

Echeneibothrium simplex, n. sp.—Plate VI., figs. 95, 96 and 97.

The species is one of the simplest of the genus to which it belongs. Its head consists of four stalked bothridia, each shaped like a violet leaf. The edge of each is divided by horizontal ridges into areolas, some twenty-two in number. It was difficult to make out the exact number. There is no myzorhynchus. The body measured 2 centims. in length. There is also no neck, the transverse divisions beginning immediately behind the head. The number of segments is about 100. They are nearly all broader than long, except the last six or seven; the anterior three of these are about square, the others are longer than broad, the last being perhaps twice as long as broad. The reproductive pores are lateral and alternate; there are often two on the same side, followed by two on the other.

The diagnosis of *Echeneibothrium simplex* is :—

Very simple leaf-like bothridia, with areolas, some twenty-two stretching right round the edge of each bothridium. No neck. Genital pores rather irregularly alternate.

Habitat :—Intestine of *Trygon walga.*

Echeneibothrium trifidum, n. sp.—Plate VI., figs. 98 and 99.

This beautiful little Cestode was taken from the spiral intestine ot *Trygon walga*, where it lived with a *Tylocephalum uarnak*. There were only three examples, which differed a little in length, but averaged 6 millims. or 7 millims. The head bears four leaf-like bothridia, stalked and very mobile. The basal or posterior half of each bothridium is single, and carries nine transversely elongated areolas. The proximal end of each bothridium is, however, split into two halves, and each half bears nine areolas, of a somewhat rounded form. There are thus altogether twenty-seven areolas, nine large and eighteen small, in each bothridium. A fine, delicate, extensile membrane edges the bothridium. These bothridia are borne on stalks which can be readily elongated and contracted, as the sketch indicates. The unsplit part is usually curled with the split part into a C. There is no myzorhynchus. The proglottides at an early stage show traces of the testes, but only the posterior half show any genital pores. These are lateral, and very irregularly alternate.

Diagnosis of *Echeneibothrium trifidum* :—

This species is characterised by its trifid bothridia with twenty-seven areolas.

Habitat :—The intestine of *Trygon walga.*

* Zschokke, 'Mem. Instit. Nat. Genev.,' xvii., 1889.

Echeneibothrium trygonis, n. sp.—Plate VI., fig. 100.

This species is much more delicate and slender than *E. minimum*. It measures from 8 millims. to 15 millims., and its greatest breadth is about 0·3 millim., if we leave out of account the head, which, when the bothridia are turned out, may attain the width of nearly 1 millim.

The head does not bear the bothridia on stalks, but the neck passes into the head like the stem of a goblet into the bowl. The head is, in fact, rather like the seat of those three-legged camp-stools upon which artists sometimes sit, only there are four instead of three legs. The bothridia face inwards, are deeply hollowed, and acting together must form a very effective sucker.

On the inner face of each bothridium are seven or eight areolas which stretch across the bothridium, and thus there is no median longitudinal line.

The head is carried on a stout unsegmented neck, which is a good deal broader than the succeeding segmented part. The proglottides, in fact, do not become thicker as they become posterior; the anterior and posterior edges of each proglottis are of the same width, and the ripe posterior proglottides are loosely attached to one another, like so many sausages, the medium which keeps them together being apparently the cuticle. In this region they are some five times as long as they are broad. The stained specimens showed no detail of structure and the specimens were too few to cut into sections.

Diagnosis of *Echeneibothrium trygonis* :—

Delicate slender form. The four bothridia spring from the neck with no stalk, and bear a single row of seven or eight transverse areolas. The posterior proglottides get thinner as they get older.

Habitat :—The intestine of *Trygon walga*.

Echeneibothrium walga, n. sp.—Plate VI., fig. 101.

This very delicate little tapeworm was found amongst a collection of *Tylocephalum trygonis* and *Echeneibothrium minimum*. Unfortunately but one specimen was taken. This measures 7 millims. in length and about 0·2 millim. in breadth. The posterior proglottides are ripe and the animal is probably full grown.

The head breaks up into four long stalks, each bearing two bothridia or rather two halves of a bothridium. The stalks appear to be permanently about 1 millim. long, though doubtless they may expand and contract within narrow limits. Each of the half bothridia faces the other and they somewhat resemble the clasping appearance of a Gecko's toes. They each contain a double row of some twelve areolas which are not rounded off towards the longitudinal median partition. Numerous muscle strands pass into each stalk after they have made a cruciform plexus in the head.

There is scarcely any neck, the narrow, straight-sided proglottides appear close behind the head. About half way along the body the proglottides are square, whilst

the mature ones at the posterior end are perhaps twice as long as broad. Here the remains of the penis are visible, and it seems to bear spicules. In the few proglottides where it is visible, the reproductive pores appear to be regularly alternate. In appearance this somewhat resembles VAN BENEDEN'S figure of one phase of *E. minimum*.* It is however, we believe, a distinct species.

The diagnosis of *Echeneibothrium walga* is as follows :—

Head provided with four long stalks, each bearing a pair of opposed half bothridia, each composed of twenty-four areolas. Body minute, neck hardly present, reproductive pores regularly alternate.

Habitat :—Intestine of *Trygon walga*.

Echeneibothrium ceylonicum, n. sp.—Plate VI., figs. 102 and 103.

Four specimens varying in length from 8 millims. to 25 millims. were taken from the intestine of *Trygon walga*. The head is comparatively small and resembles in general architecture the head of *Echeneibothrium trygonis*, but it differs considerably in details. The head itself is longer and takes up a greater proportion of the whole body. It splits into four short arms, and each of these bears a bothridium. The bothridia are built up of fourteen areolas, of which one is terminal at each end and twelve are paired, as in the figure (Plate VI., fig. 103). Special muscles run from each arm down the neck, and the several arms are very mobile and contractile and take on different shapes in different states of contraction.

The body is stouter than in the case of *Echeneibothrium trygonis*; the neck is of fair length ; the proglottides bulge out a good deal at the sides, so that the outline is like a thread of beads. The reproductive pore is median. The mature proglottides are never more than twice as long as they are broad, and their sides are curved, not straight and parallel. Mixed with the adults were a number of young forms, with tapering bodies, but not yet divided into proglottides.

The diagnosis of *Echeneibothrium ceylonicum* may run :—

Length up to 25 millims. Head with four inwardly directed bothridia, bearing fourteen areolas; of these, two are terminal and twelve are paired. Proglottides rounded at the side, the oldest, ready to break off, never more than twice the length of the breadth. Reproductive pore median.

Habitat :—Intestine of *Trygon walga*.

Phyllobothrium lactuca, VAN BENEDEN.—Plate VI., figs. 104 (*a* and *b*) and 105.

This is by far the longest Cestode found in *Trygon walga*. It attained in one preserved specimen the length of 33 centims. In this particular specimen the width hardly exceeded 2 millims., and the texture was flimsy and soft, but in another specimen, which was in pieces, the consistency of the worm is stiff and almost brittle, and the width had swollen out to 4·5 millims. and, although broken up, its length could have

* 'Mem. Ac. Belgique,' xxv., 1850, Plate ii., fig. 3.

exceeded 150 millims. The width gradually increased as we passed backwards until the last half dozen proglottides, which narrowed a little (Plate VI., fig. 104). When alive the worm was in all probability much longer; they contract when being killed.

The head resembles the figs. 2 and 3 of VAN BENEDEN'S pl. iv. of his "Recherches sur les vers cestoïdes,"* which represent *Phyllobothrium lactuca*, but the bothria are more definitely arranged in four, and the edge, which is crinkled and ruched, has not such a square section (Plate VI., fig. 105). The neck is very long. The proglottides all through the body are broader than they are long, except the posterior six or seven, which are slightly longer than they are broad. Each proglottis overhangs the ones which follow it, and thus its posterior border is wider than its anterior. The sides are oblique and, as the figures show, slightly wrinkled.

Habitat:—Intestine of *Trygon walga*.

Tylocephalum trygonis (SHIPLEY and HORNELL).

Tetragonocephalum trygonis, SHIPLEY and HORNELL.

Several specimens of this species were found in the intestine of *Trygon walga*. They permitted one to observe what was not recorded in the original description,† that the genital pores are very irregularly alternate. Thus in one specimen, using R for right and L for left, the genital pores were arranged as follows:—R 6, L 2, R 1, L 2, R 1, L 1, R 1, L 1, R 3, L 1, R 2, L 2, R 3, L 2, and so on. In the posterior segments the pore is very large and stands out from the proglottis just as the portion which bears the leaf stands out from a bare twig of a chestnut tree in winter.

Tetrarhynchus equidentatus, n. sp.—Plate VI., figs. 106 and 107.

This is, I think, the largest *Tetrarhynchus* I have seen, and it is certainly very large to come from the alimentary canal of an Elasmobranch. Unfortunately but one specimen was taken, and this measured 4·7 centims. in length, not a very great length; but it is the breadth which gives the magnitude to this animal. It is almost uniformly 3 millims. broad from one end to the other, though it increases very slightly as we pass backward, but the last proglottis is narrowed. It is perhaps 0·3 millim. thick.

Compared with the size of the body, the head is very small, and the muscular sheaths come right up to the anterior end of it, and thus there are no more or less coiled tubes between them and the base of the exserted proboscides. The proboscides bear spiral or rather obliquely placed rings of hooks; the hooks are all of precisely equal size and most regularly arranged. They are 0·049 millim. in length. The head bears laterally well-marked lappets or bothridia. It is succeeded by an unsegmented region

* 'Mem. Ac. Belgique,' xxv., 1850.

† This Report, Part III., p. 51.

which is about 2 to 2·5 times the length of the head. This region terminates, as in *Tetrarhynchus herdmani*, in a well-marked collar with somewhat scalloped edge. The collar hangs back and overlaps the body region.

The divisions between the proglottides are anteriorly very insignificant, but they soon become distinct and the proglottides become a little longer. The total number is between one and two hundred. But they are never very long, never even square. The posterior proglottides are always some six or seven times as long as they are broad, and the anterior perhaps twice as much again. Their edges are rounded, there is no trace of overlapping, and in the latter half of the body the reproductive organs cause an opaque patch in each segment.

The diagnosis of *Tetrarhynchus equidentatus* is :—

Very small head, muscular proboscis sheaths reach anterior end of head ; unsegmented region, terminating in a well-marked collar, follows head ; proglottides, 100 to 200 in number, always much broader than long, rounded edges, no overlapping. Proboscis hooks same size throughout, arranged in regular obliquely placed rows.

Habitat :—Intestine of *Trygon walga*, MÜLL. and HENLE.

Tetrarhynchus herdmani, n. sp.—Plate VI., figs. 108 and 109.

The second species to *Tetrarhynchus*, found in the alimentary canal of *Trygon walga*, and later in the same position in *Rhynchobatus djeddensis*, is a long and comparatively slender one. We had only three or four specimens, which averaged about 30 millims. in length. The head is small, about 1 millim. in length. It has two well-developed lappets which, as usual, are very contractile and extensile. The four proboscides emerge from very short muscular sheaths, which lie near the posterior limit of the head. Instead of being half as long as the head, as is often the case in the Tetrarhynchidæ, they are perhaps one-twelfth to one-tenth the head length. The proboscides which emerge from them are slender and covered with minute teeth, all of the same size, arranged in spiral rows. The teeth are about 0·01 millim. in length.

The most characteristic feature of this Cestode, but one which it shares with *T. equidentatus*, to be described is a peculiar fold or collar which hangs back from the head and covers the anterior part of the neck. This collar seems to be very extensile. In the figure drawn from the live specimen, its border of free edge is scalloped, but in the specimens in spirit the collar seems more retracted and the free edge is smooth and undivided.

The neck is very short. Almost immediately after the head the proglottides are indicated by sharp lines. There are some 80 to 100 proglottides present, all separated from one another by clear, horizontal, and in no case concave, lines. Till the proglottides become packed with eggs, the lateral contours are also straight and parallel ; there is no overlapping. Thus the Cestode does not increase in width until we get to the posterior proglottides, and in these the presence of the eggs entails a

slight lateral swelling, so that this end is almost moniliform. The eggs are about 0·07 millim. in length.

In the centre of each of the last half dozen proglottides is a large clear place. This may possibly be the remains of the genital atrium, and if it is so, this is median.

Tetrarhynchus herdmani is characterised by having a small head with well-developed bothridia, short muscular proboscis sheaths, one-tenth to one-twelfth the length of head, teeth on proboscis, uniform in spiral lines, 0·01 millim. in length, well-developed collar, 60 to 100 proglottides, most with parallel sides.

Habitat :—Stomach of *Trygon walga* and *Rhynchobatus djeddensis*, Müll. and Henle.

Tetrarhynchus macrocephalus, n. sp.—Plate VI., figs. 110, 111 and 112.

At least six different species of *Tetrarhynchus* are found in the intestine of *Trygon walga*. This species is a short, stout, thick-set form, with large bothridia or lappets, which, however, when the proboscides are extended, are far less conspicuous than when they are retracted (Plate VI., fig. 110).

The total body length averages 7 millims. or 8 millims., and the body is stiff and straight. The relative length of the different parts of the body in one specimen, whose total length was 8 millims., was 3 millims. for the part of the head traversed by the coiling ducts of the proboscis sheath, 3 millims. for the part of the head which contains the muscular proboscis sheath, and 2 millims. for the rest of the body. The second portion, that which contains the muscular sheath, is the thickest, and its walls are smooth ; the anterior half of the head is wrinkled.

The four proboscides were in some specimens extended, but not fully ; they attained a length of some 2 millims. Each bears a longitudinal double row of minute, almost straight spines, diverging from one another (Plate VI., fig. 111), the whole producing the effect of a stitch known, I believe, to housewives as "herring-boning." This lies the whole length of the proboscis. There are also very numerous sharply hooked spines, which lie in transverse rows some hundred or more in number. Each of these rows consists of some ten or twelve hooks, grading in size from the largest, which is just opposite the "herring-boning," to the smallest, which flank the "herring-boning."

When the whole is retracted it passes first into the very coiled ducts of the muscular sheaths, which are very apparent in the specimen.

The strobila is smaller than either half of the head ; the piece immediately succeeding the head is anteriorly concave, and receives into its concavity the convex end of the head (Plate VI., fig. 110). It soon begins to "segment," and the proglottides grow rapidly. They are few in number, and the most posterior, which is about the tenth or twelfth, is almost as large as all the others put together. It shows clearly the exit of the water vascular system. The specimens were probably young ones.

Diagnosis of *Tetrarhynchus macrocephalus* :—

The characteristic features of this species are the relatively enormous head, the few —some ten or twelve—proglottides, the "herring-bone" spicules on the proboscides, and the arrangement and grading of the hooks on the same.

Habitat :—The stomach and intestine of *Trygon walga*.

Tetrarhynchus platycephalus, n. sp.—Plate VI., figs. 113 and 114.

This is a moderate-sized form, measuring 10 millims. or 12 millims. in length. The head and neck occupy about one-sixth of the whole body length. The head is compressed from front to back and spreads out laterally, having something the appearance of a Toreador's hat. The four-hooked proboscides bend out towards the edge of the hat, and finally emerge at the angles (Plate VI., fig. 114). The hooks are large, sabre-like, and of uniform size.

The body consists of ten or eleven segments, the last two of which are as big as the rest of the body altogether. The proglottides are at first some six times as broad as they are long, but the fourth or fifth proglottis is already square, and the last is perhaps four or five times as long as broad. They are rounded and plump, stouter half way along than at either end, and stouter in front than behind. The most characteristic feature is the genital pore. This is a great cleft which runs almost half across the proglottis and seems to half cut it in two. This appears already in the fourth or fifth proglottis, and gives the appearance of an irregular and abnormal segmentation. The pores are lateral and alternate as a rule, though now and then two will consecutively follow each other on the same side.

The diagnosis of *Tetrarhynchus platycephalus* is as follows :—

Head much flattened, proboscides coming out of the edges of the flattened head. Hooks uniform in size, sabre-like. Proglottides ten or eleven in number, broader in the middle than at either end. Reproductive pore resembles a huge cleft, which seems to half cut the proglottis in two; alternate, but slightly irregular.

Habitat :—The intestine of *Trygon walga*.

Tetrarhynchus rubromaculatus (Diesing).—Plate VI., figs. 115 and 115*a*.

This is by far the smallest of the Tetrarhynchids found in *Trygon walga*. Only two specimens were taken, one measuring 4 millims., the other 7 millims. in length. The head occupies nearly half this length, and the proboscis sheaths, which vary a little in the two specimens, are nearly half the length of the head (Plate VI., fig. 115).

The bothridia are distinct even when the proboscides are protracted. The latter are four in number and bear sickle-shaped spines, not arranged in very definite rows; between some of them are short rows of minute straight spines.

Behind the head the body consists of six or seven proglottides: the first two of these are band-like, the third longer, the fourth about square, the fifth twice as long as broad, the sixth and seventh four to five times as long as broad. In one specimen

the posterior proglottis bore a lateral eminence, presumably the genital pore, which much resembled the similar process figured by WAGENER* in a *Tetrarhynchus* taken from a *Trygon pastinaca*.

In some notes which Mr. HORNELL sent with the material, he states that in the bottle which contained the *E. trygonis* were two species of Tetrarhynchid, one with collar and the other with red pigment anterior to the muscle sacs. Now, as a matter of fact, there were four species of Tetrarhynchids in the bottle, and two of these were collared forms. Thus there is a reasonable degree of probability that the species we are describing, although colourless in spirit specimens, had a reddish patch in front of the muscular proboscis sheaths. In his figure of the *Tetrarhynchus* taken from a *Trygon pastinaca*, WAGENER paints a bright red splash just in this place. Neither WAGENER's figure nor DIESING's† diagnosis, given under the name *Rhynchobothrium rubromaculatum*, descend into any details, which might not apply to many Tetrarhynchids, yet there is nothing in the figure or in the diagnosis which differs materially from what we find in our specimens, and on the whole we seem justified in regarding these as belonging to the species *T. rubromaculatus* (DIESING).

Habitat:—The intestine of *Trygon walga*.

Tetrarhynchus ruficollis (EYSENH.)—Plate VI., figs. 116, 117.

Several specimens of this worm were taken from the intestine of *Trygon walga*. They measure 40 millims. to 50 millims. and had the characteristic criss-crossing of the proboscis sheaths. The teeth are not quite so regular as in VAN BENEDEN's specimens, and he does not figure any of the posterior proglottides; these are cylindrical and smooth, the same diameter throughout and eight to ten times as long as they are broad. They are so cylindrical that it is impossible to say if the genital pore is on the edge or median. There are besides the larger teeth, arranged in more or less oblique rows, two longitudinal chains of very minute tubercles.

VAN BENEDEN's specimens came from *Mustelus vulgaris*, MÜLL. and HENLE, ours came from the intestine of *Trygon walga*, MÜLL. and HENLE.

MARGARITIFERA VULGARIS, SCHUM.

Finally, we insert the pearl oyster as a host to complete the series.

Tetrarhynchus unionifactor, SHIPLEY and HORNELL—Plate VI., fig. 118.

A few specimens in the same stage as those described and figured in Part II. of this work, p. 88 and Plate II. But what is of greater interest was the discovery of a number of still younger forms of the same species in the stomach and alimentary canal of the oyster. These are quite small forms 1 millim. in length; and they

* 'Acta Ac. German,' xxiv., 'Supl. Taf.,' xxi., 253.

† 'S.B. Ak. Wien.,' xlviii., 1863, 1st Abth., p. 292.

consist of hardly anything more than the head, but the little piece of body shows some slight traces of the markings at the hinder end of the large larval form (see Part II., Plate II., fig. 20). The arrangement of the lappets, the proboscides, the proboscis sheath and the proboscis tubes are similar to those of the older larvæ, and so, as far as it could be made out, and that was by no means completely, was the shape and arrangement of the teeth in the proboscides.

Assuming—for we have as yet no absolute proof—that the youngest form of *T. unionifactor* forms the nucleus around which the pearls are deposited, we have in this lately found larval form an explanation of how the species is preserved. Of the given number of larvæ which enter at a very early stage into the body of the Oyster a certain number arrive in the mantle and other tissues, acquire an ectodermic sac and there encyst, and find a costly grave in the developing pearl. The remainder, however, reach the alimentary canal and grow and flourish there. When they attain the dimensions of the stages described in Part II., they leave the alimentary canal and encyst usually upon the outer surface of the intestine. Now they are too big for enclosure in a pearl, and they can wait without anxiety for the advent of their second host (*Rhinoptera javanica*) within whose intestine they rapidly become sexually mature. It is not entirely impossible that these Tetrarhynchids are different species, though at present the evidence is in favour of the two being different stages of the same species. If they are different species, the smaller probably corresponds with the smaller pearl-forming larvæ described in the previous paper (this vol., p. 22).

Further specimens of the Trematode *Aspidogaster margaritiferæ* were also collected.

II. NEMATODA.

Professor M. Stossich, of Trieste, whose untimely death has deprived us of a most helpful friend, has supplied us with the names and in some cases with short descriptions of the few Nematodes collected on this occasion.

AETOBATIS NARINARI (Euphrasen).

Spiropterina scillicola, v. Ben.

Aetobatis narinari is a new host for this species.

CARCHARIAS MÜLLERI, Müll. and Henle.

Ascaris, sp.

An embryonic form too young to be identified.

MARGARITIFERA VULGARIS AND PLATAX TEIRA.

Ascaris meleagrinæ, LINSTOW.

Part II. of this work, p. 99.

Platax teira is a new host for this species. The stomach of *Platax teira*, one of the "sea-bats," contained numbers of Octopuses entangled with Lumbriconereids and Eunicidæ. This Nematode also lives in *Balistes mitis* and *B. stellatus*.

Echinocephalus gracilis, n. sp.

The following account of this new species is due to the late Professor M. STOSSICH: "In the pearl oyster, *Margaritifera vulgaris*, there lives the larva of a Nematode, which LINSTOW recently ascribed to the species, *Echinocephalus uncinatus*, a species created by MOLIN for the form living in the Adriatic *Trygon*, but in comparing these with some of the examples of *E. uncinatus* from the Adriatic, it is evident that they are entirely different, and neither belong to the species of LINSTOW or of MOLIN. I therefore create a new species, *Echinocephalus gracilis*, with the following diagnosis:—

"Body about 12 millims. long, caudal end hooked and twisted; the head is surrounded with a spherical swelling of the cutis, covered with six transverse rings of hooks, each containing some 40 to 50 hooks; these hooks resemble closely those of certain *Echinorhynchus*, and consist of a large half imbedded in the skin and of a free blade; they gradually increase in size from the first to the sixth row. The mouth is surrounded by six lips, the dorsal and ventral are the largest and are truncated at their outer end, the four lateral have their free end distinctly crenated.

"Habitat:—*Margaritifera vulgaris*, in the adductor muscle."

STEGOSTOMA TIGRINUM, GÜNTHER.

The stomach of this fish contained the feet of Gastropods and remains of Pleurobranchi.

Acanthocheilus nidifex, LINTON.

Allied species occur in *Mustelus vulgaris*, *M. laevis*, *Scyllium catulus*, *S. stellare*, *S. canicula*, and other Elasmobranchs.

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* I. Refers to the first report on Parasites, in Part II.
II. Refers to the second report on Parasites, in Part III.
III. Refers to the present report on Parasites, in Part V.

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NATIVE NAMES OF ELASMOBRANCH FISHES.

We add a list of such native names of Elasmobranchs in use in the North of Ceylon as we have so far been able to ascertain, together with the scientific designation. Where possible the signification of the native names is given.

We are well aware that the list is far from complete. It is offered in lieu of anything fuller being in existence, and in the hope that it may prove of assistance to anyone who may pursue investigation in Ceylon touching the Elasmobranchs.

Preliminary List of the Native Names of Elasmobranchs in Use in the North of Ceylon.

Species.	Native name.	Signification.
Aetobatis narinari (Euphrasen)	Pua tirikkai, Tamil. Pulli-maduwa, Sinhalese.	Spotted Ray.
Carcharias melanopterus, Quoy and Gaim.	Kunda mōra, Sinh.	
Chiloscyllium indicum (Gmel.)	Kurakan sura, Tam.	Kurakan-shark (Kurukan = *Eleusine coracana*).
Chirocentrus dorab (Forsk.)	Valai or Walai, Tam. Katuwalla, Sinh.	Bunch of thorns.
Dicerobatis eregoodoo (Russell)	Koppu tirikkai, Tam. Kombu tirikkai, Tam. Añga maduwa, Sinh.	Horned Ray.
Mustelus manazo, Bleeker	Pāl sura, Tam.	Milk-shark.
Myliobatis maculata, Gray and Hardw.	Panjadi tirikkai, Tam. Panjadiya maduwa, Sinh.	
Narcine timlei (Bl. Schn.)	Hiri maduwa, Sinh. Timilī, Tam.	Numbing ray-fish. Numbing fish.
Pristis cuspidatus, Latham	Vēlā-mīn, Tam. Dētī mōra, Sinh.	Sawfish. Saw-shark.
Pristis zyson, Bleeker	Illīpā, Tam.	
Pteroplatea micrura (Bl. Schn.)	Attavănnai tirikkai, Tam.	
Rhinobatus sp.	Gāl uluwa, Sinh. Kāl uluvi, Tam.	Rock uluwa. Rock plough-fish.
Rhinoptera adspersa, Müll. and Henle	Sankkudi tirikkai, Tam. Mundeikanni tirikkai, Tam.	Chank-eating Ray (Madura coast). Goggle-eyed Ray (North of Ceylon).
Rhinoptera javanica, Müll. and Henle	Valvadi tirikkai	Gregarious Ray.*
Rhynchobatus djeddensis (Forsk.)	Kiri-uluwa, Sinh. Uluwa mōra, Sinh. Pāl-ūlūvī. Tam.	Milk-uluwa. Uluwa-shark. Milk plough-fish.
Stegostoma tigrinum (Gmel.)	Komorin sura, Tam. and Pullian sura, Tam.	Comorin-shark. Spotted-shark.
Trygon kuhli, Müller and Henle	Kātti tirikkai, Tam.	Ray with boils.†
Trygon sephen (Forsk.)	Adā tirikkai, Tam. Polkolla maduwa, Sinh.	Coconut-leaflet Ray.‡
Trygon uarnak (Forsk.)	Pullian tirikkai, Tam.	Spotted Ray.
Trygon walga, Müll. and Henle	Mānāl tirikkai, Tam.	Sand Ray.
Urogymnus asperrimus (Bl. Schn.)	Kālli tirikkai, Tam. Erabadu maduwa, Sinh.	Prickly-pear Ray. Erabadu§ Ray.
Zygæna blochi, Cuvier	Udalŭ mōra, Sinh. Komban sūra, Tam.	Pickaxe-shark. Horned-shark.

* From its habit of going about in great shoals.

† A reference to the boil-like appearance of the large blue spots upon the disc.

‡ This name has reference to the resemblance borne to the pinna of a coconut leaf by the tail and its cutaneous fold.

§ Erabadu, the tree *Erythrina indica*, L., which has the trunk and branches studded with strong prickles.

EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1. *Cephalobothrium aetobatidis.* × 10. Entire worm, drawn from preserved specimen.
,, 2. The head of the same. × about 35.
,, 3. The head of the same, drawn from life. × about 40.
,, 4. The head of the same, drawn from life. × about 40.
,, 5. Anterior end of *Hornellobothrium cobraformis*, with the suckers expanded. × about 100.
,, 6. The same, with suckers retracted. × about 100.
,, 7. Outline of edge of body in anterior broad region.
,, 8. The same, in the narrower posterior region.
,, 9. Body of *H. cobraformis*, × 45, drawn from stained specimen.
,, 10. Enlarged view of head, × about 450, showing button-like myzorhynchus and the extended suckers.
,, 11. *Kystocephalus translucens.* × 16. The head in this specimen is rather diagrammatic.
,, 12. Head of *Kystocephalus translucens*, × about 50, showing the terminal myzorhynchus.
,, 13. *Myzocephalus narinari.* × 10.
,, 13*a*. Posterior proglottis. × about 40.
,, 14. Head of *Myzocephalus narinari.* × about 40.
,, 15. The same simplified and opened out to show myzorhynchus. × about 40. Semi-diagrammatic.
,, 16. *a*, *b*, *c*. Bothridia on myzorhynchus, showing outline of shapes assumed.
,, 17. *Myzophyllobothrium rubrum.* × 6. (17.)
,, 17*a*. ,, proglottis from the middle of the body. × 25.
,, 17*b*. ,, last proglottis. × 25.
,, 18. ,, head. × 25.

PLATE II.

Figs. 19, 20, 21. *Myzophyllobothrium rubrum*, drawn from living specimens, showing various views of the head. The red pigment spots are represented by black dots.
Fig. 22. *Tetrarhynchus aetobatidis.* × 12.
,, 23. ,, extremity of a proboscis. × about 100.
,, 24. ,, showing the more sabre-like teeth at the base of the proboscis, and the position of the red granules.
,, 25. *Tetrarhynchus*, sp. Young form with no proglottides formed. × 40.
,, 25*a*. ,, Tip of proboscis. × about 150.
,, 26. A series of teeth of the above, showing the gradations of a single ring.
,, 27. *Tetrarhynchus*, sp. Young form with cyst still present. × about 75.
,, 27*a*. Proboscis and teeth of the same.
,, 28. *Tetrarhynchus gangeticus*, head. × 20.
,, 28*a*. ,, Still further enlarged view of proboscis.
,, 29. *Tetrarhynchus perideraeus.* × 12. Showing the coiled portion of the body.
,, 30. ,, the head. × 36.
,, 30*a*. More highly magnified view of the proboscis of the same.
Figs. 31*a*, *b*, *c*. Three views of proglottides of *T. perideraeus*, showing the modification in the pattern as one passes backward.

PLATE III.

Fig. 32. *Phyllobothrium minutum.* × 20.
,, 33. ,, head. × 80.
,, 34. *Phyllobothrium pammicrum.* × 10.
,, 35. ,, head. × 70.
,, 36. *Tetrarhynchus carcharidis.* × 20.
,, 37. ,, head. × about 40.
,, 38. *Carpobothrium chiloscyllii.* × 100.
,, 39. ,, single bothridium. × 150.
,, 40. Anterior end of a *Tetrarhynchus* cyst from *Chirocentrus dorab*, enclosed in a secondary cyst formed from the tissues of the host. × 20.
,, 40*a*. The whole cyst. × 2.
,, 41. View of the *Tetrarhynchus* when the cyst has been ruptured.
,, 42. Very young *Tetrarhynchus* from *Cybium guttatum*, × 25, showing also shape and arrangement of teeth.
,, 43. Cyst of *Tetrarhynchus* from *Cybium guttatum*, highly magnified.
,, 44. Tetrarhynchid cyst, × 30, from *Diagramma*, sp.
,, 45. Head of *Anthobothrium crispum.* × 10.
,, 46. A few segments of *Anthobothrium crispum*, × about 12, showing the characteristic L markings.
,, 47. Head of *Diagonobothrium asymmetrum.* × about 30.
,, 48. Head of *Rhoptrobothrium myliobatidis.* × about 66.
,, 49. *Tylocephalum dierama*, the entire animal × 6, and two more highly magnified sketches of proglottides to show the extent of the overlap.
,, 50. Head of *Tylocephalum dierama.* × about 60.

PLATE IV.

Fig. 51. *Echeneibothrium javanicum.* × 22. An enlarged view of the striated cuticle is shown to the left.
,, 52. A sketch of the same from life, showing the bothridia divaricated.
,, 53. Another sketch from life, showing the bothridia concentrated.
,, 54. A single bothridium, showing the areolas.
,, 55. A transverse section through the neck of the same, showing the fine excretory canal, the two nerve-cords, and bundles of muscles.
,, 56. A transverse section through the head, showing the hollows of the four bothridia and their areolas.
,, 57. *Echinobothrium rhinoptera*, magnified. *p.* penis; *p.h.*, enlarged view, the hooks of the penis; *s.r.*, spinous region.
,, 58. Head of the same, more highly magnified.
,, 59. Spine from the spinous region, very highly magnified.
,, 60. *Eniochobothrium gracile.* × 30. Rather diagrammatic sketch from life.
,, 61. The body of the same. × 30. Drawn from a preserved specimen.
,, 62. More highly magnified view of head and anterior end of body of *Eniochocephalum gracile.*
,, 63. *Tetrarhynchus unionifactor.* × 8. *a.*, enlarged view of a proboscis, showing arrangement of teeth; *b.*, a tooth still more enlarged.
,, 64. The same, drawn when alive, showing the anterior meeting of the two bothridia and the apical emergence of the proboscides.
,, 65. *Tiarabothrium javanicum.* × 16. Drawn from a spirit specimen.

Fig. 66. Head of the same, × about 50, drawn from life. *c.*, collar. *w.v.*, excretory canals.
,, 67. Longitudinal median section through the head of *Tiarabothrium javanicum*. *a.*, areola of bothridium. *c.*, collar contracted.
,, 68. Transverse section through the collar region of the same. *c.*, collar. *n.*, neck.
,, 69. *Tetrarhynchus rhynchobatidis.* × 4.
,, 70. The head of the same. × about 18.
,, 71. End of a proboscis of the same, × about 100, showing the curiously reversed teeth.

PLATE V.

Fig. 72. *Phyllobothrium blakei.* × 20
,, 73. The head of the same. × about 50.
,, 74. *Rhinebothrium ceylonicum.* × 2, drawn from the contracted preserved specimen.
,, 75. Head of the same, × about 5, drawn from the living specimen.
,, 76. *Tylocephalum kuhli.* × 20.
,, 77. The head of the same. × 60.
,, 78. *Anthemobothrium pulchrum.* × 8. *a.*, proglottis from middle; *b.*, from end of body.
,, 79. Head of the same. × 40.
,, 80. *Prosthecobothrium trygonis.* × 1·5.
,, 81. Head of the same. × 36.
Figs. 82*a* and *b*. Hooks from the head of *Prosthecobothrium trygonis*, highly magnified.
Fig. 83. *Tetrarhynchus leucomelanus.* × 2.
,, 83*a*. Proglottis from middle of the body, showing longitudinal striations.
,, 84. Head of the same, × about 30, with tip of proboscis highly magnified.
,, 85. *Tylocephalum uarnak.* × 10.
,, 86. Head of the same. × 40.
,, 87. *Tetrarhynchus macroporus.* × 10. *a.*, posterior segment, × about 30; *b.*, portion of the proboscis highly magnified.
,, 88. *Thysanobothrium uarnakense.* × 2.
,, 89. Head of the same. × about 20.
,, 90. Posterior view of head of the same. × about 20.
,, 91. Another view of head of the same. × about 20.
,, 92. *Anthobothrium rugosum.* × 7.
,, 93. *Echeneibothrium minimum*, highly magnified, with the bothridia expanded.
,, 94. The same, less highly magnified, with the bothridia contracted.

PLATE VI.

Fig. 95. *Echeneibothrium simplex.* × 6.
,, 96 Head of the same, from a spirit specimen. × 35.
,, 97. The same, from life. × 35.
,, 98. *Echeneibothrium trifidum*, magnified.
,, 99. Head of the same, more highly magnified.
,, 100. *Echeneibothrium trygonis.* × 20.
,, 101. *Echeneibothrium walga.* × 26.
,, 102. Anterior end of *Echeneibothrium ceylonicum*, magnified.
,, 103. Head of the same, more highly magnified.

Fig. 104. *Phyllobothrium lactuca*, VAN BEN. ×2. *a.*, outline of proglottides about middle of body; *b.*, the same from posterior part of body.

,, 105. Head of *Phyllobothrium lactuca*. ×6.

,, 106. *Tetrarhynchus equidentatus*. ×4.

,, 107. Proboscis of the same. ×50.

,, 108. *Tetrarhynchus herdmani*. ×6.

,, 109. The head of the same. ×60.

,, 110. *Tetrarhynchus macrocephalus*. ×10.

,, 111. View of the concave side of a proboscis of the same.

,, 112. View of the convex side of a proboscis of the same.

,, 113. *Tetrarhynchus platycephalus*. ×10.

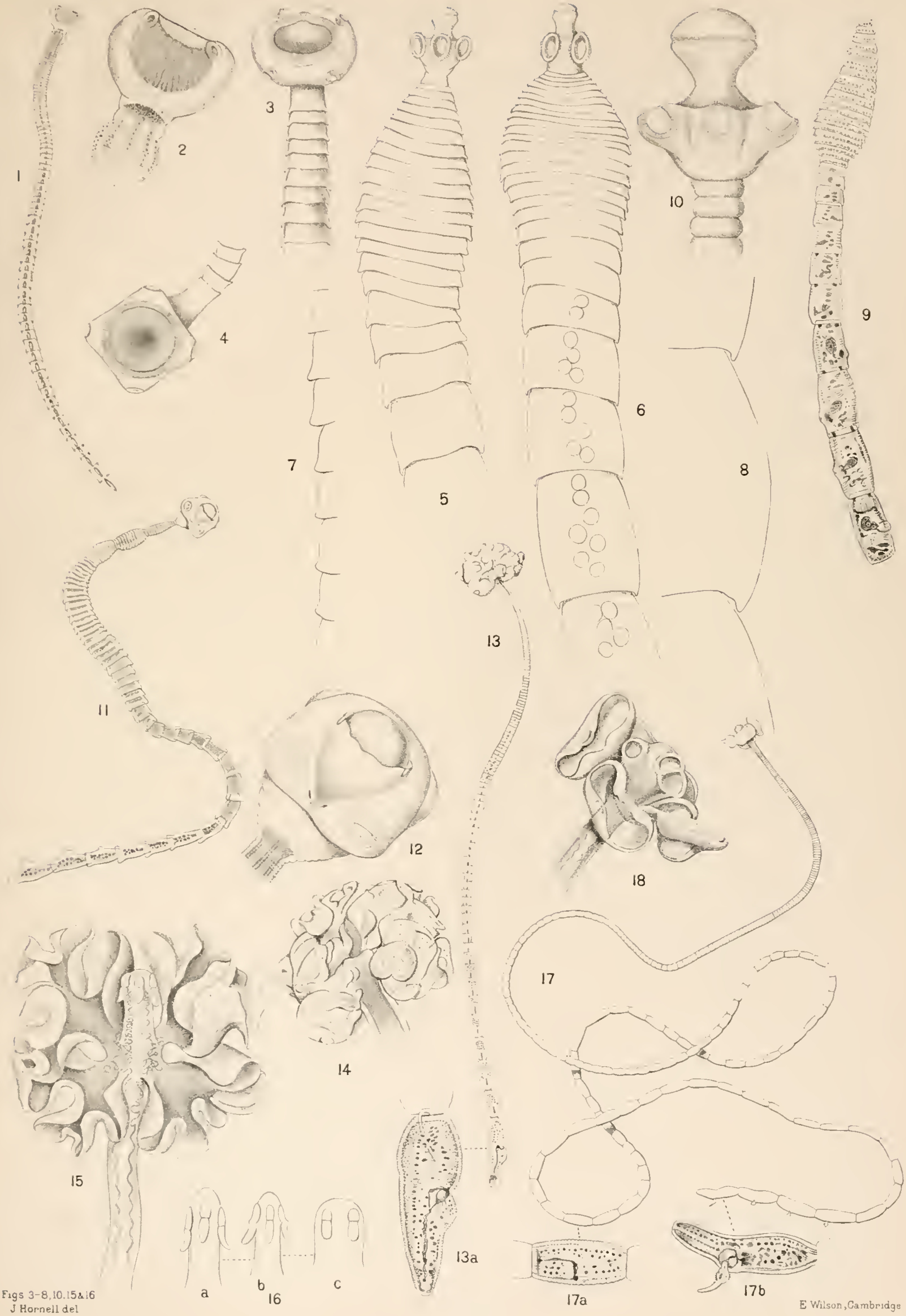
,, 114. Head of the same. ×45.

,, 115. *Tetrarhynchus rubromaculatus* (DIESING). ×40. *a.*, a further enlarged view of the end of a proboscis.

,, 116. *Tetrarhynchus ruficollis* (EYSENH.). ×6.

,, 117. Head of the same. ×12. *a.*, further enlarged view of the end of a proboscis.

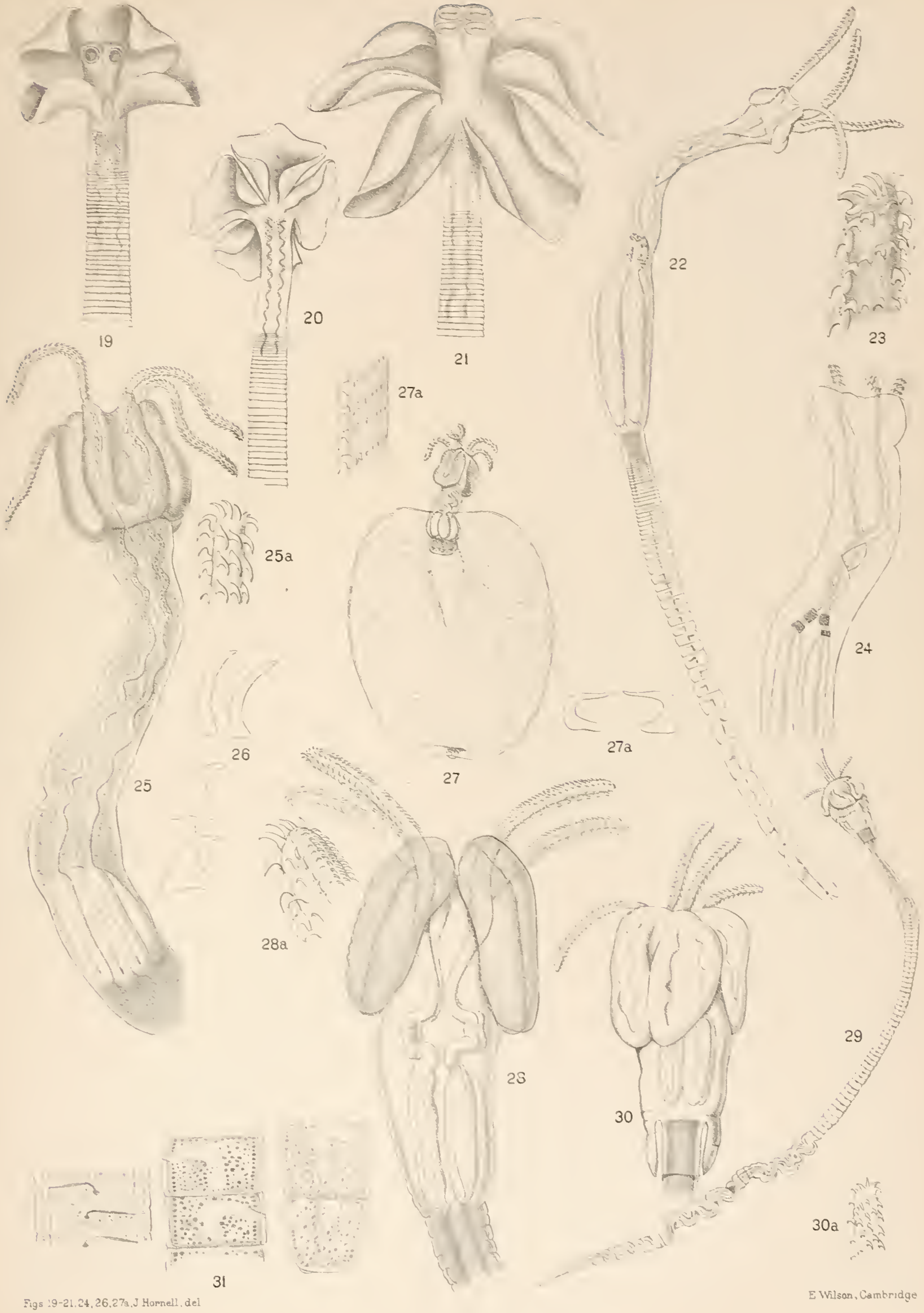
,, 118. *Tetrarhynchus unionifactor*, × about 100, from alimentary canal of pearl oyster.



Figs 3-8, 10, 15 & 16
J Hornell del

E Wilson, Cambridge

PARASITES



Figs 19-21, 24, 26, 27a, J. Hornell, del

E. Wilson, Cambridge

PARASITES.

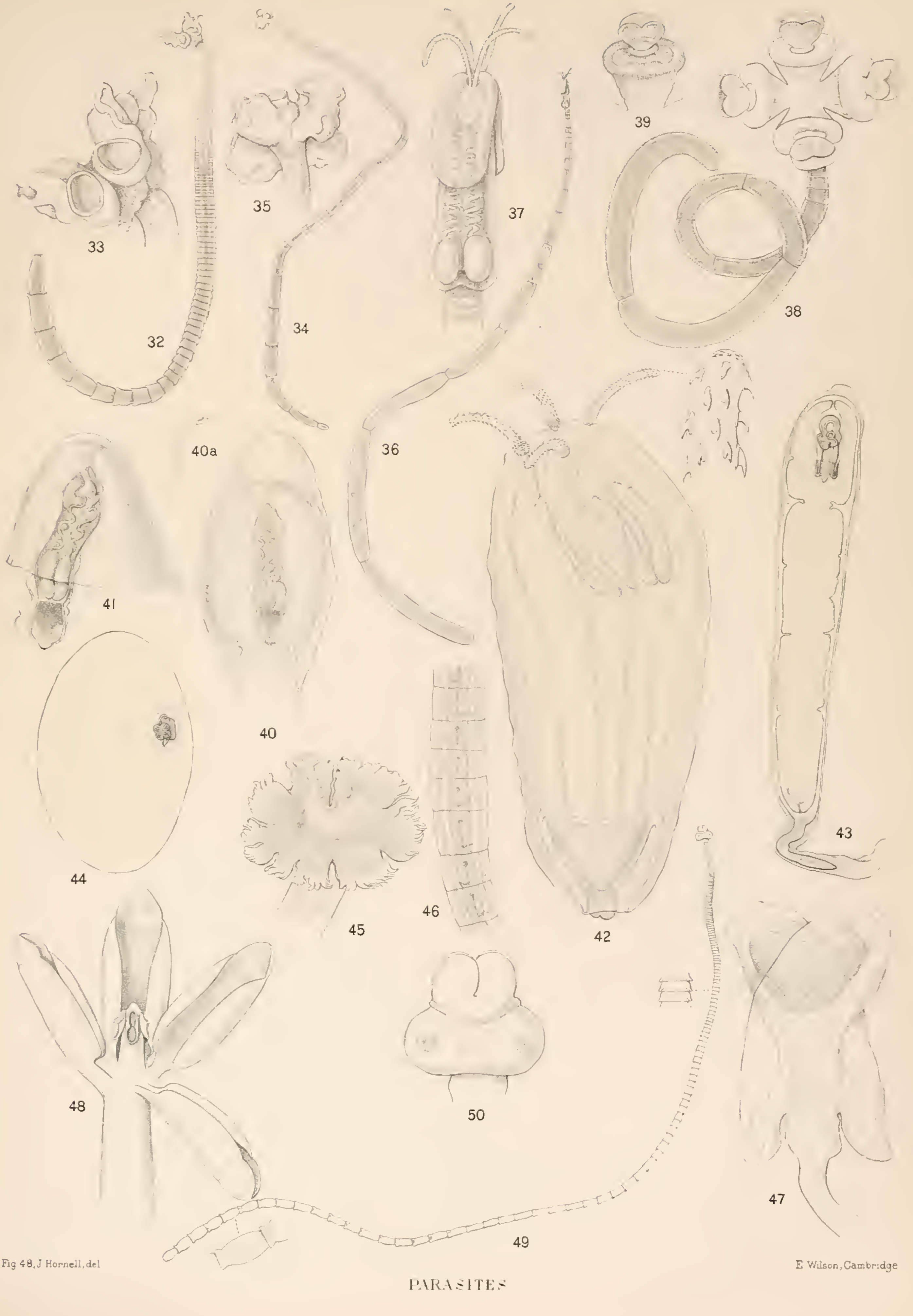


Fig 48, J Hornell, del

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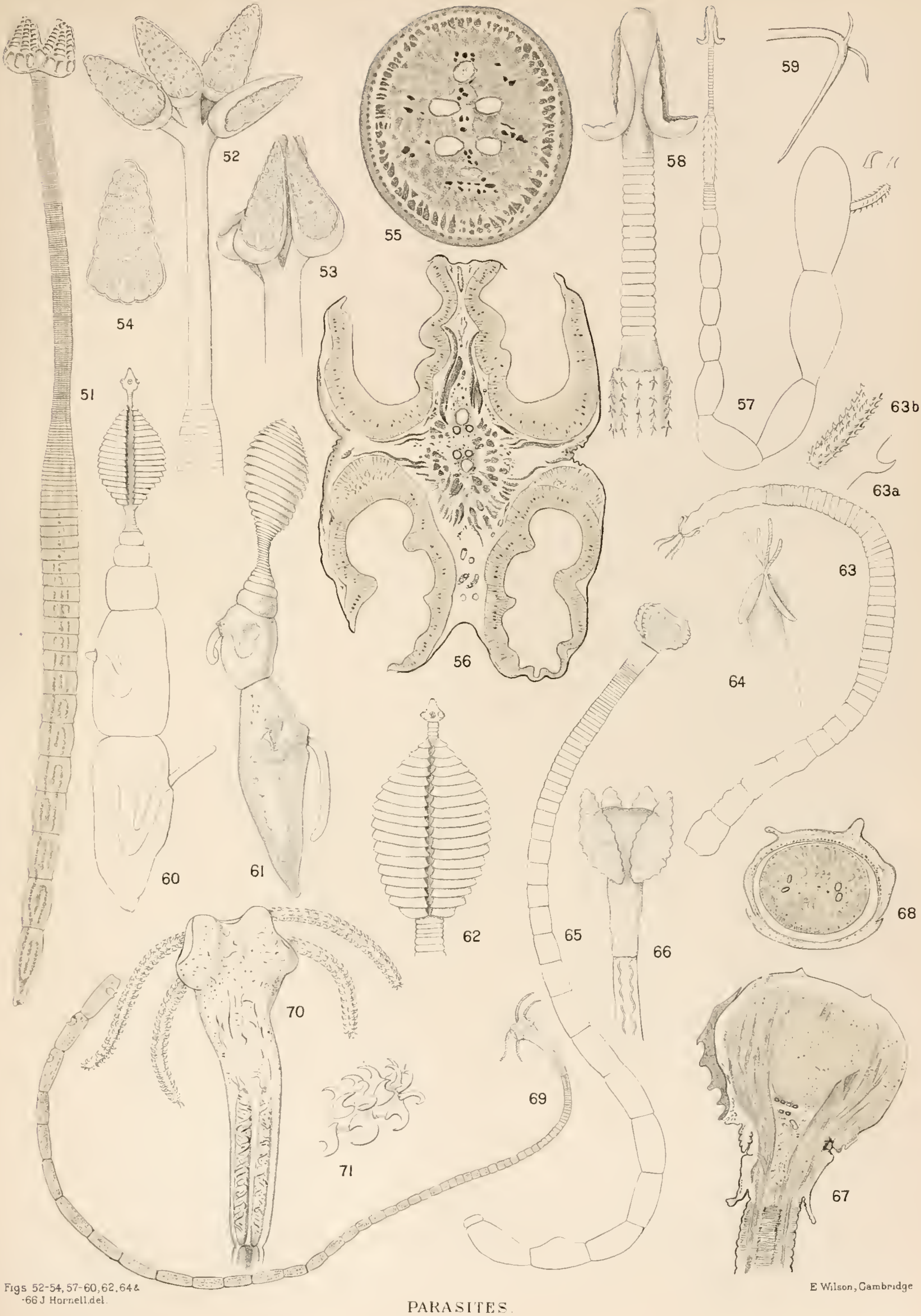
PARASITES



Figs 52-54, 57-60, 62, 64 & -66 J Hornell, del.

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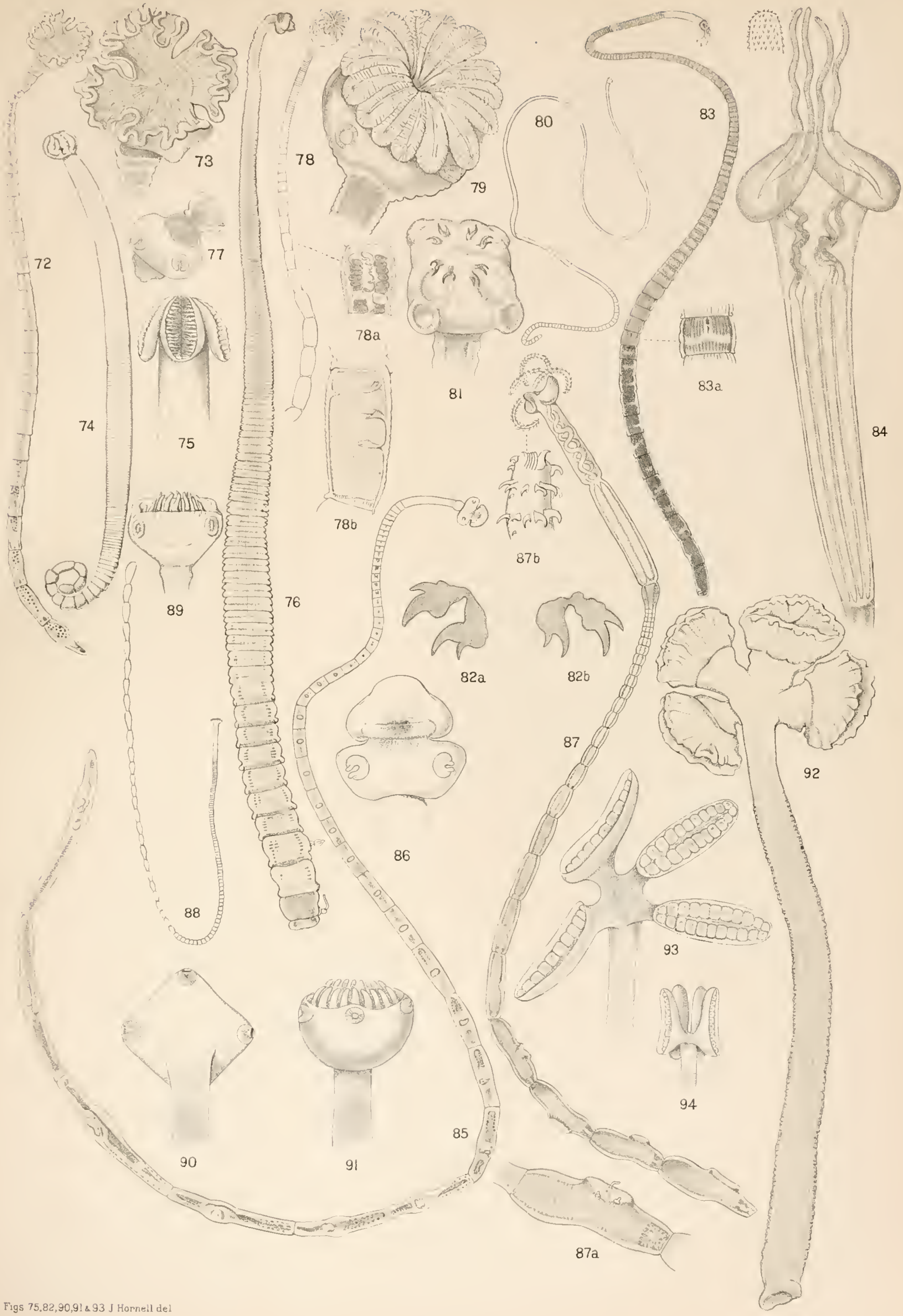
PARASITES.



Figs 75,82,90,91 & 93 J Hornell del

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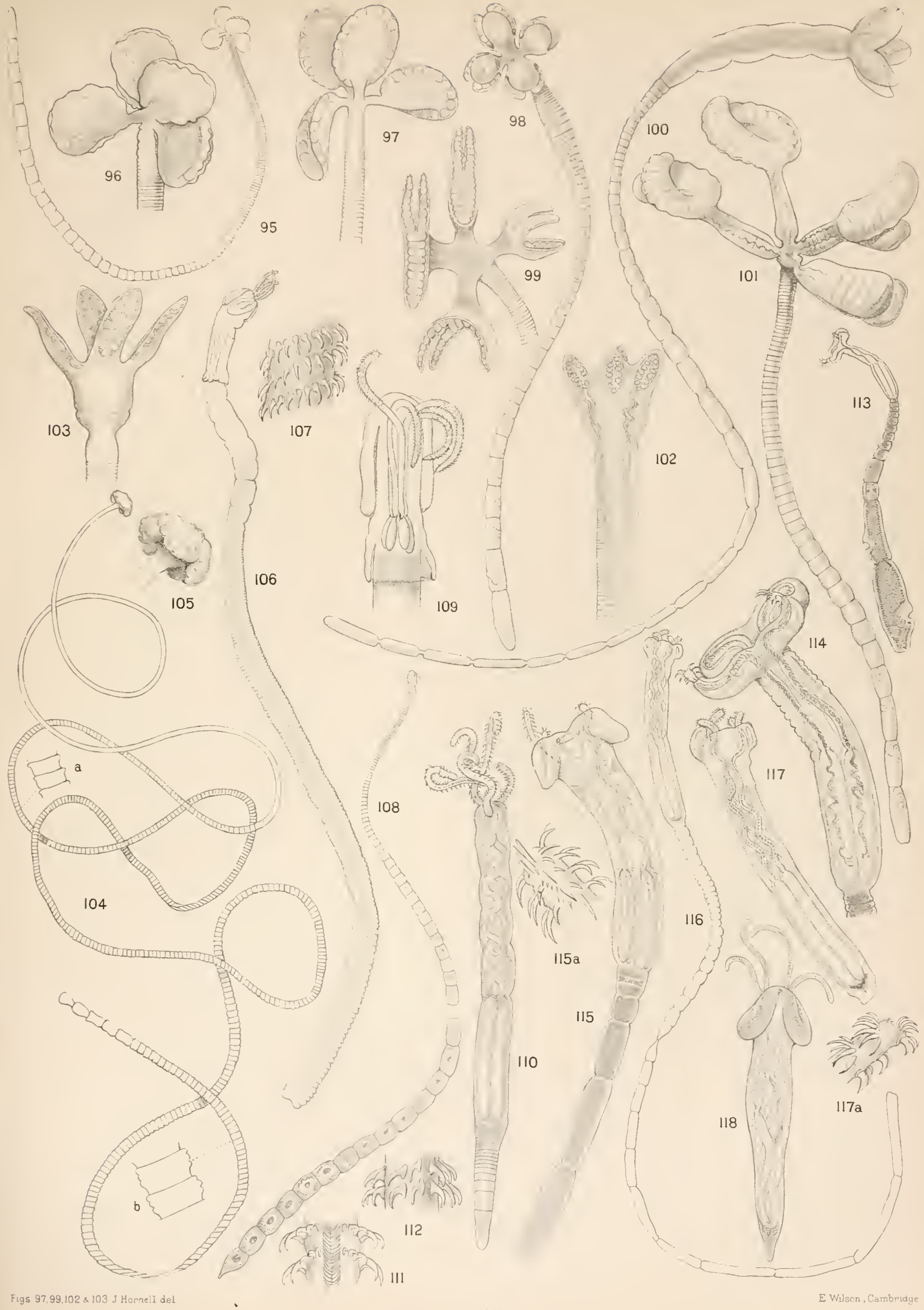


Figs 97, 99, 102 & 103 J Hornell del

E Wilson, Cambridge

PARASITES

REPORT

ON THE

TREMATODE PARASITES

FROM THE

MARINE FISHES OF CEYLON.

BY

MAX LÜHE, Ph.D.,
KÖNIGSBERG IN PREUSSEN.

[With TWO PLATES.]

By the kindness of Mr. A. E. Shipley,* to whom I wish to express here my warmest thanks, I have had the opportunity of studying a very interesting collection of Trematodes, mostly parasites of fishes, obtained from Ceylon by Professor Herdman and Mr. Hornell. The collection contained seven different species, all of which are new to science. They are described below.

One of the seven species belongs to the ectoparasitic Trematoda or Heterocotylea. Two are larval forms of Distomids, one of which, however, is a well-distinguished species of the genus *Stephanochasmus*, Looss, the systematic position of the other larva being still doubtful. Of the four adult Distomids contained in the collection, three belong to new genera.

Epibdella (Benedenia) macrocolpa, n. sp.—Plate I., figs. 1 to 3.

From the skin of *Rhinoptera javanica*, Müll. and Henle.

1. Kalpitiya.—Three specimens in bottle No. 36 (the type specimens).
2. Dutch Bay.—Two specimens in bottle No. 2.

Body oval, flattened; length 9 millims. to 10 millims., breadth 5 millims. to 7 millims. The two anterior suckers well developed, circular, with a diameter of about 1 millim., connected together by a thin membranous continuation of the

* These Trematodes were sent to Mr. Shipley with the other parasites (see preceding Report) and were by him sent on to Dr. Lühe for description.—W. A. Herdman.

anterior end of the body. Posterior sucker oval, with a longitudinal diameter of 2·3 millims. to 2·6 millims. and a broadest transverse diameter (a little before the middle of the sucker) of 2·1 millims. to 2·4 millims., with three pairs of hooks very similar in form and arrangement to those of *Benedenia hendorffi* (v. LINST.), and with four pairs of notches on the hinder half of its margin, due to the insertion of muscular fibres, the third of these notches just behind the third pair of hooks.

Mouth behind the plane of the hinder margin of the anterior suckers; œsophagus wanting. On the cerebral ganglion are two pairs of eyes; the posterior eyes a little larger than the anterior ones and directed forwards and outwards, the anterior eyes directed backwards and inwards.

Genital openings on the left lateral edge of the body, near the anterior end, by the side of the anterior sucker; the opening of the vagina just behind the common genital pore. Testes large, two in number, paired, irregularly round. Ovary large, elliptical, with its longer axis at a right angle to the longer axis of the body, situated in the median line, just in front of the testes and midway between the anterior end of the body and the centre of the posterior sucker. Vitellarium extending from the anterior end of the body, between the two suckers, to about the front end of the posterior sucker, that of the two sides intermingling with each other both in front of the cerebral ganglion and behind the testes. Paired yolk ducts directed transversely to the long axis of the body, uniting together near the median line just in front of the ovary. Unpaired yolk duct dilated to form a capacious yolk reservoir, situated in front of the left half of the ovary. The thinner end of the unpaired yolk duct unites soon with the oviduct, which arises from the middle of the anterior border of the ovary and proceeds forward. The canal arising from the united oviduct and yolk duct runs from about the median line to the left, undergoing several convolutions and opening into the ootype, which lies in the same line with the left border of the ovary. It has a characteristic rhomboid shape and is continued into the short uterus. The vagina is exceedingly long (hence the specific name *macrocolpa*); it arises from the yolk reservoir at its left border, and running on the left side of the body, outside the ovary and the testes, turns in a varying level between the hinder border of the testes and the front margin of the posterior sucker lateral and oral, and then proceeds orally, almost in a straight line, to reach the left margin of the body, at about the level of the hinder margin of the anterior suckers. Vasa efferentia relatively long, uniting with each other on the left side of the ovary; the vas deferens runs in an almost regularly curved line round the left side of the ovary and yolk-reservoir, and forms a large, close pack of numerous complicated convolutions between the ootype and the yolk-reservoir, then turning tailwards in a curved line and entering the penis in about the median line, a little in front of the ovary. Penis long, running in a curved line round the shell glands, ventral from the curved end of the vas deferens, and oral from the right half of the ovary, and entering into the very long genital atrium, which reaches the median line just before the ootype.

Stephanochasmus ceylonicus, n. sp.—Plate I., figs. 4 to 6.

From the subcutaneous tissue of *Narcine timlei*, Henle, taken off Dutch Bay, Ceylon. Several specimens.

Of this species only the encysted larval form was found, but there can be no doubt that the species is a new one, although closely allied to *Stephanochasmus pristis* (Deslongch.).

The specimens are about 2·0 millims. to 2·6 millims. in length, and 0·25 millim. broad. Margins of oral sucker projecting laterally over the thinner neck. Diameter of oral sucker 0·18 millim. to 0·2 millim., of ventral sucker 0·18 millim. Distance between the two suckers 0·6 millim. Length of præpharynx 0·4 millim. Pharynx 0·126 millim. in length, and 0·056 millim. broad. Round the mouth a double wreath of 36 large spines, which is not interrupted ventrally, as it is in *Stephanochasmus cesticillus* (Molin). The larger spines of the first row are 0·059 millim. and the somewhat smaller spines of the second row are 0·056 millim. in length. The small spines of the general body surface are best developed close behind the oral sucker, and become gradually smaller posteriorly, though more numerous. Behind the level of the ventral sucker the skin acquires the finely spinous structure described by Looss for *Hæmatolœchus asper*, Lss., and the posterior half of the body is smooth. Of the genital organs only the two testes, situated near the posterior end, are visible. The excretory vesicle is Y-shaped, with a short but ample median trunk, and two long branches reaching almost to the oral sucker.

The worms were encysted in round cysts, with a diameter of the outer wall of about 0·5 millim. to 0·8 millim., and of the inner wall of about 0·36 millim. to 0·47 millim. According to Mr. James Hornell, who collected the worms and has made drawings from the living objects, the fluid filling the space in the cyst around the larva was granular. In an uninjured cyst which I examined this fluid seemed quite clear.

Sub-family: ACANTHOCOLPINÆ, nov.

Provisional diagnosis.—Distomids with a very elongate and but slightly muscular body, whose cross-section is round or oval. Ventral sucker near the anterior end of the body. Oral sucker terminal or subterminal, but always cup-shaped, never funnel-shaped, followed mostly by a very distinct tubular præpharynx. Pharynx well developed, œsophagus short, intestinal cœca long, reaching almost to the posterior end of the body.

The two testes situated in the posterior part of the body, one behind the other, their axial diameter longer, more or less, than their transverse diameters. Cirrus-pouch long and slender, cirrus with spines. Ovary in front of the testes, median or sub-median. Vitellarium formed by numerous little follicles, situated on the sides of the body and behind the testes (in *Stephanochasmus* and *Acanthocolpus*) or only

on the sides of the body (in *Deropristis* and in *Distomum semiarmatum*). Uterus running directly oral (in *Stephanochasmus* and *Acanthocolpus*), or at first tailwards and then turning in front of the testes (in *Deropristis*), or reaching the posterior end of the body (in *Distomum semiarmatum*). Vagina always very distinct and provided with similar spines to the cirrus. Genital atrium tubular, almost without spines, but sometimes (in *Acanthocolpus*) in its posterior part with similar spines to the vagina and cirrus. Genital opening in front of the ventral sucker in the median line.

From the generic differences mentioned in this diagnosis it results that *Acanthocolpus* is much more closely related to *Stephanochasmus* than to *Deropristis* and to *Distomum semiarmatum*.

Acanthocolpus, n. gen.

Provisional Generic Diagnosis:—Distomids of small size, with a thin, slender, very elongated body, round or oval in cross-section, without spines in the skin and around the mouth, with a transverse section of oval shape, rounded behind, somewhat pointed in front. Neck not enlarged Ventral sucker near the anterior end of the body somewhat pediculated. Oral sucker subterminal, followed by a very distinct præpharynx. Pharynx well developed, not far in front of the ventral sucker. Œsophagus short. Intestinal cœca long, ending not very far in front of the posterior end of the body.

Genital opening just before the short stalk of the ventral sucker in the median line. The two testes are oval shaped, with the longest diameter in about the long axis of the body, situated near the posterior end of the body in the median line, just behind each other. Ovary just in front of the testes. Very numerous follicles of yolk glands on the sides of the body and behind the testes, reaching the posterior end of the body.

Uterus developed in the same manner as in *Stephanochasmus*, opening into a very distinct long vagina, which bears on its inner side numerous spines; cirrus-pouch very long, vesicula seminalis and pars prostatica lying on the dorsal side of the uterus; cirrus of about the same length and with similar spines to the vagina. Cirrus and vagina opening into a long, tubular, genital atrium, the posterior half of which bears likewise similar spines to the cirrus and vagina. The spines are of a very characteristic shape, much broadened, and excavated at their bases. Eggs yellow-tinted.

This new genus, the type, and till now only species, of which is *Acanthocolpus liodorus*, is allied to the genera *Stephanochasmus*, Lss., and *Deropristis*, Odhn., and to another genus hitherto still unnamed, the type species of which is *Distomum semiarmatum*, Mol., a parasite of the sturgeon, found by me several years ago at Trieste, but the description of which I have not yet published, since another helminthologist, to whom I have sent my drawings, intended to write a special report upon the Trematode parasites of the sturgeon.

The above-named genera form together a separate sub-family, which I have named Acanthocolpinæ, the spines in the vagina being one of the striking characters.

Acanthocolpus liodorus, n. sp.—Plate I., figs. 7 and 8.

Specific diagnosis.—Length 2 millims. to 4 millims., breadth 0·36 millim. to 0·6 millim. Diameter of the oral sucker 0·12 millim. to 0·16 millim. Ventral sucker oval, with the largest diameter transverse to the long axis of the body; length 0·18 millim. to 0·24 millim. and breadth 0·24 millim. to 0·3 millim. Distance between the two suckers 0·24 millim. to 0·36 millim.

Præpharynx 0·21 millim. to 0·24 millim. long. Pharynx 0·13 millim. to 0·17 millim. long, 0·08 millim. to 0·10 millim. broad. Genital atrium 0·4 millim. to 0·7 millim. long, dividing behind the ventral sucker. Vagina about 0·25 millim. to 0·5 millim. long. Cirrus-pouch about 0·5 millim. to 1·05 millims. long, 0·07 millim. to 0·10 millim. broad. The long axis of the testes not quite in the long axis of the body, but somewhat oblique, the posterior end directed ventrally and the anterior end directed dorsally, and the two testes overlapping each other a little in this way. Ovary near the ventral surface of the body, partially still ventral from the anterior end of the anterior testes. The testes 0·35 millim. to 0·60 millim. long, 0·20 millim. to 0·24 millim. broad. Diameter of the ovary 0·14 millim. to 0·22 millim. Eggs 0·075 millim. long, 0·045 millim. broad.

From the intestine of *Chirocentrus dorab*, Cuv.; from Kalpitiya. About two dozen specimens.

Schistorchis, n. gen.

Provisional generic diagnosis.—Distomids of large size, with a very muscular, thick and wrinkled body, without spines. Shape almost rectangular, with rounded anterior and posterior ends. Mouth terminal, small, opening into the globular oral sucker. Pharynx well developed; præpharynx as well as œsophagus wanting; intestinal cœca long. Excretory vesicle Y-shaped, with long median trunk and long paired branches, crossing the intestinal cœca ventrally and finishing near the anterior end of body by the sides of the oral sucker.

Genital opening just in front of the ventral sucker. Cirrus-pouch well developed.

Testes in about the middle of the body, divided into several small separated pieces (in the same manner as in *Gorgodera*), five on the one side, and six on the other, lying for the most part behind each other in two lateral folds, which are separated from each other by the anterior end of the median trunk of the excretory vesicle. As in *Gorgodera*, the greater number of testes is on the ovarian side.

Ovary just in front of the testes and between the paired branches of the excretory vesicle, near the median line. Seminal receptacle present. Very numerous follicles of yolk glands on the sides of the body and behind the testes. Uterus very small, corkscrew-like, almost only by the side of the ventral sucker. Eggs clear yellow-tinted.

Type, and so far the only species of the genus: *Schistorchis carneus*, n. sp.

Schistorchis carneus, n. sp.—Plates I. and II., figs. 9 to 12.

Specific diagnosis.—Blood red tinted during lifetime, about 10 millims. to 15 millims. long, and about 4 millims. to 6 millims broad. Diameter of the oral sucker about 2 millims. to 2·5 millims., of the ventral sucker about 0·8 millim. to 1·0 millim. The oral sucker, in all the specimens examined, somewhat retracted, not reaching the outer surface of the body. Distance between the two suckers at the most 0·9 millim.

Pharynx much broader than long, 0·8 millim. by 0·3 millim. in the largest specimen, 0·6 millim. by 0·3 millim. in a smaller one. The intestinal cœca run in the beginning transversely outwards, then, after turning in almost a right angle, slightly convergent to the posterior end of the body. In several specimens they are filled with a dark matter. The paired branches of the excretory vesicle cross the transversely running beginnings of the intestinal cœca, and finish at the level of the greatest diameter of the oral sucker.

Diameter of the single testes reach 0·6 millim. to 1·0 millim. in the largest specimen. Cirrus-pouch with a large vesicula seminalis, which lies in the median line just behind the ventral sucker and opens in the pars-prostatica, turning round the left side of the sucker. Ovary near the median line, just behind the cirrus-pouch, and of about the same size as the single testes. Receptaculum seminis behind the ovary or at the left of it. Both ovary and receptaculum seminis in the triangle between the paired branches of the excretory vesicle, which unite just behind them. Vitellarium beginning at the level of the ovarium or of the vesicula seminis.

From the stomach of *Tetrodon stellatus*, GÜNTHER; from South Modragam Paar, Ceylon Pearl Banks. Eleven specimens.

General Remarks on Distomids with Numerous Testes.

Already several genera of Distomids with an increased number of testes are known. With some of these, *Syncœlium*, LSS., *Otiotrema*, SETTI, *Hapalotrema*, LSS., this new genus has no affinity at all. Also with the above-named *Gorgodera*, LSS., it has no close resemblance beyond the number and arrangement of the testes. However, the resemblance is far greater with the genus *Pleorchis*, RAILL., the anatomy of which, it is true, is but little known as yet; but the general arrangement of the genital organs is the same in *Pleorchis* as in *Sinistorchis*. The two species of *Pleorchis* also being intestinal parasites of marine fishes, it seems quite possible that the new genus is allied to *Pleorchis*, which differs, however, from it in several important points, justifying the creation of a new genus for the Ceylonese species described above. For *Pleorchis* is provided with spines in the cuticula, with a greater number of testes (24 to 30), with a long præpharynx, and with anterior branches of the intestinal cœca, similar to, though smaller than, the anterior branches of the H-shaped intestine of *Accacœlium*.

Referring to the species of *Pleorchis*, I must justify the mention of two species,

although only one is quoted in the literature since the establishment of the genus *Gorgodera* for *Distomum cygnoides*, ZED. = *Pleorchis cygnoides*, STOSS. This only species is *Pleorchis polyorchis* (STOSS.), an intestinal parasite of the Mediterranean *Corvina nigra*. To the same species LINTON has referred an intestinal parasite of the North-American *Cynoscion regalis*, which I regard as a different species and which I will name *Pleorchis americanus*, n. sp. Besides the different habitat, the two species differ from each other in several important points of their anatomy; a distinct œsophagus is wanting in *Pl. polyorchis*, but present in *Pl. americanus*, and the anterior branches of the intestine are short and run parallel to the main branches in *Pl. polyorchis*, but are somewhat longer and form an angle with the larger intestinal cœca in *Pl. americanus*. In the latter species, moreover, the size of the two suckers seems to be smaller than in *Pl. polyorchis* (according to the figures given by STOSSICH and LINTON), and the number of testes somewhat larger than in *Pl. polyorchis*, which, according to STOSSICH, is provided constantly with 24 testes, whilst LINTON has counted 26 to 30 in *Pleorchis americanus*. It is of interest, that in this species also, as in *Gorgodera* and in *Sinistorchis*, the number of the testes is different on the two sides. In one specimen only LINTON found 15 testes on each side, and in another 15 on the right and 12 on the left, while of nine specimens with 14 testes on the right, two were provided with 16, three with 15, two with 13, and two with 12 testes on the left.

Gastris, n. gen.

Provisional generic diagnosis.—Distomids of large size, with a very muscular body, without spines. Anterior part of the body, between the two suckers, ventrally excavated; posterior part of the body, behind the ventral sucker, broadened, oval-shaped.

Oral sucker subterminal; pharynx well developed; œsophagus short; intestinal cœca long, and finishing not very far in front of the posterior end of the body.

Excretory system U-shaped, with long branches, situated between the intestinal cœca. Genital opening about midway between the two suckers, in the median line. Cirrus-pouch large, oval-shaped, situated in the angle between the two intestinal cœca.

The two testes globular, situated nearly symmetrically side by side, touching laterally the intestinal cœca and separated from each other by the uterus. Ovary in front of the testes near the median line. Yolk glands in the posterior half of the body, laterally to the intestinal cœca, arranged in several (6 to 7) groups, which lie behind each other and are separated from each other by a small interspace, in the same manner as in the genus *Opisthorchis*, R. BL. Uterus running at first to a little extent forwards, but turning very soon, proceeding then posteriorly and reaching the level of the blind ends of the intestinal cœca, not extending laterally beyond the

branches of the excretory vesicle, but filling the whole space between these branches and behind the testes in numerous loops very densely pressed together. Eggs very dark, almost black.

At first view the arrangement of the genital organs of specimens somewhat compressed exhibits a superficial resemblance with *Dicrocœlium*, but closer examination exhibits no intimate affinity between this and the new genus.

Gastris consors, n. sp.—Plate II., figs. 13–16.

Specific diagnosis.—Length up to 16 millims.; just behind the ventral sucker 1·5 millims. to 1·7 millims. broad; greatest breadth about midway between the ventral sucker and the posterior end of the body up to $5\frac{1}{2}$ millims.

Oral sucker circular, with a diameter of 1·0 millim. to 1·1 millims. Ventral sucker oval, with a greater diameter transverse to the long axis of the body of 2·6 millims. to 2·8 millims., and a smaller diameter parallel to the long axis of the body of 2·0 millims. to 2·2 millims. The opening of the ventral sucker is a transverse slit. Distance between the two suckers 1·6 millims.

Pharynx 0·6 millim. long, 0·84 millim. broad. Intestinal cœca end 1·8 millims. in front of the posterior end of the body, in several specimens filled with a dark matter.

Cirrus-pouch about 0·8 millim. long, about 0·5 millim. broad. Testes in about the middle of the body; vitellarium beginning at the level just behind the testes and not reaching the level of the blind ends of the intestinal cœca.

From *Tetrodon stellatus*, GÜNTHER.—Four specimens along with *Schistorchis carneus*, found apparently also on South Modragam Paar and also in the stomach of the host.

Anaporrhutum largum, n. sp.—Plate II., fig. 17.

From the body cavity of *Rhinoptera javanica*; Kalpitiya. A single specimen.

Body very flat, membranous, smooth, oval, 9 millims. long, 8 millims. broad; the greatest breadth just behind the ventral sucker.

Oral sucker subterminal, oval, with a longitudinal diameter of 0·65 millim. and a transverse diameter of 0·8 millim. Ventral sucker very large, but little excavated, slightly oval, with a longitudinal diameter of 2 millims., and a transverse diameter of 2·2 millims. Distance of the two suckers from each other 1·5 millims. Distance of the posterior margin of the ventral sucker from the posterior end of the body 4·8 millims.

Pharynx 0·42 millim. long and 0·48 millim. broad, not projecting into the oral sucker (as it does in *A. albidum*, OFENH.). Œsophagus short, about 0·6 millim. long. Intestinal cœca large and long, end about 1 millim. in front of the posterior end of the body, embracing a space smaller than that between their outer edge and the lateral margins of body. This broadening of the parts outside the intestinal cœca, together with the excessive diameter of the ventral sucker and the extreme thinness of the

whole body, gives to the species a characteristic appearance, different from that of the other Anaporrhutinæ.

Excretory vesicle Y-shaped, with long median trunk, dividing a little behind the level of the posterior end of the yolk glands, and with shorter paired branches not crossing the intestinal cœca, but ending at the sides of the posterior edge of the ventral sucker.

Genital openings ventral from pharynx, somewhat at the right of the median line. Cirrus-pouch wanting.

Testes outside the intestinal cœca, but still within a distance of almost 2 millims. from the lateral margins of the body, extending from 0·5 millim. behind the posterior margin of the ventral sucker to 1·8 millim. behind the same. Their number is 14 at the right side of the body and 17 at the left side, pressed closely together in two rows which unite behind; the inner edge of these rows has but about half the length of the outer. Each testis is mulberry-shaped. The vasa efferentia from the single testes arise between the two rows and unite soon to form the vas deferens of each side. The two vasa deferentia do not anastomose with each other, as they are said to do in *A. albidum*, but only unite at about the level of the division of the intestinal cœca to form a very convoluted vesicula seminalis.

Ovary globular, with a diameter of 0·4 millim. It is situated just behind the ventral sucker, at the right side of the body. Receptaculum seminis of about the same size, situated at the side of the ovary in the median line. Yolk glands between the intestinal cœca and the paired branches of the excretory vesicle, the left just behind the ovary, and the right symmetrically on the other side of the body, each of them consisting of several tubules, which do not anastomose with each other, as they are said to do in *Anaporrhutum albidum*, Ofenh., and *Probolitrema capense*, Looss.*

Uterus similar to that of *Probolitrema richiardi* (Lop.) Lss., but ending about 0·7 millim. in front of the blind end of the intestinal cœca, and passing at the right side of the ventral sucker.

The new species *Anaporrhutum largum* differs from both *Anaporrhutum albidum*, Ofenh., and the two species of the genus *Probolitrema*, Lss. (*P. richiardi* and *P. capense*), in several points of its anatomy, especially in the position of the testes and the yolk glands, to which Looss has ascribed generic value. Accepting *Probolitrema* as a separate genus, it would be necessary therefore to create a third genus for the new species. But doubtless all these Anaporrhutinæ living in the body cavity of Selachians are more closely related to each other than to *Plesiochorus cymbiformis* (Rud.), placed by Looss in the same sub-family. It seems to me, therefore, that *Probolitrema* is to be regarded only as a sub-genus of *Anaporrhutum*, or

* In addition to *Anaporrhutum largum* I have also examined a species of *Probolitrema* very similar to *P. richiardi* (Lopez), if not identical with this, which is found in an undetermined shark from the Ulle Sea (Dutch India), and belongs to the Natural History Museum of Hamburg (No. 17705). In this species also the tubules of the yolk glands do not anastomose with each other.

that *Plesiochorus* is to be regarded not as a member of the Anaporrhutinæ themselves, but as the representative of a separate sub-family of the Gorgoderidæ allied to the Anaporrhutinæ.

Distomum, sp. (larva).—Plate II., fig. 18.

From *Pinna*, sp. One specimen.

A small larva of a Distomid, about 1 millim. long, and about 0·36 millim. broad, without spines. Ventral sucker very large, projecting, situated in the posterior half of the body, its distance from the posterior end of the body 0·20 millim., its diameter 0·33 millim. Diameter of the oral sucker 0·18 millim., of the pharynx 0·12 millim. Œsophagus wanting. Intestinal cœca ending at about the middle of the body. Excretory vesicle V-shaped, ending at about the same level as the posterior end of the intestinal cœca.

From the genus *Gymnophallus*, larval forms of which are found in some marine Lamellibranchs (*Mytilus edulis*, *Saxicava rugosa*), this parasite of *Pinna* differs in the absence of spines in the skin, of a distinct œsophagus, of an unpaired median trunk of the excretory vesicle, and by the smaller length of the excretory vesicle.

BIBLIOGRAPHY.

1902. Jameson, H. Lyster.—"On the Origin of Pearls." 'Proc. Zool. Soc. London,' 1902, vol. i., p. 140.

1881. Levinsen, G. M. R.—"Bidrag til Kundskab om Gronlands Trematodfauna." 'Oversigt over d. K. D. Vidensk. Selsk. Forhandl.,' etc., 1881, No. 1, p. 52.

1901. Linton, Edwin.—"Parasites of Fishes of the Woods Hole Region." 'U.S. Fish Commission Bulletin for 1899,' p. 405.

1894. Looss, A.—"Die Distomen unserer Fische und Frösche." 'Bibl. Zool.,' Heft 16.

1899. Looss, A.—"Weitere Beiträge zur Kenntniss der Trematodenfauna Ägyptens," &c. 'Zoolog. Jahrb.,' Abtlg. f. Syst., Band xii., Heft 5–6, p. 521.

1901. Looss, A.—"Über die Fasciolödengenera *Stephanochasmus*, *Acanthochasmus* und einige andere." 'Centrbl. f. Bakter.,' etc., I. Abtlg., Band xxix., Nos. 14, 15, and 16.

1902. Looss, A.—"Über neue und bekannte Trematoden aus Seeschildkröten. Nebst Erörterungen zur Systematik und Nomenklatur." 'Zoolog. Jahrb.,' Abtlg. f. Syst., Band xvi., Heft 3–6, p. 411.

1905. Lühe, M.—"Über die Entstehung der Perlen." 'Schriften d. Physik.-ökonom. Gesellsch. Königsberg in Pr.,' Jahrg. xlv., 1904, pp. 79–83.

1893. Monticelli, Fr. S.—"Studii sui Trematodi endoparassiti." 'Zoolog. Jahrb.,' Suppl. iii.

1900. Odhner, Th.—"*Gymnophallus*, eine neue Gattung von Vogeldistomen." 'Centrbl. f. Bakter.,' etc., I. Abtlg., Band xxviii., No. 1, p. 12.

1902. Odhner, Th.—"Mitteilungen zur Kenntniss der Distomen."—II. 'Centrbl. f. Bakter.,' etc., I. Abtlg., Orig.-Band xxxi., No. 4, p. 152.

1905. Odhner, Th.—"Die Trematoden des arktischen Gebietes." 'Fauna arctica,' hrsg. v. F. Römer und F. Schaudinn, Band iv., Lief. 2, p. 289.

1900. von Ofenheim, E.—"Über eine neue Distomidengattung." 'Zeitschr. f. Naturwissensch., Band lxxiii.

1889. Stossich, Michele.—"Brani di Elmintologia Tergestina."—VI. 'Boll. d. Soc. Adriatica di scienze naturali in Trieste,' vol. xi.

1898. Stossich, Michele.—'Saggio di una fauna elmintologica di Trieste e provincie contermini. Trieste, 1898, 8°, 162 pgg. (Estr. del 'Programma della Civica Schola Reale Superiore' pubblicato alla fine dell' anno scolastico 1898.)

EXPLANATION OF PLATES.

PLATE I.

Fig. 1. *Epibdella (Benedenia) macrocolpa*, n. sp. Ventral view. × 10. (For letters, see fig. 3.)

„ 2. Posterior sucker of the same species, with the three pairs of hooks. × 20.

„ 3. Genital organs of the same species. × 30.

cg., cerebral ganglion with the two pairs of eyes; *ev. ev.* (only in fig. 1), excretory vesicles; *ga.*, genital atrium; *ic. ic.*, intestinal cœca; *ln. ln.*, longitudinal nerve; *oot.*, ootype; *ov.*, ovary; *p.* penis; *ph.*, pharynx; *t.*, testes; *ut.*, uterus; *v.* vagina; *ve.*, vasa efferentia; *vi.* (only in fig. 1), vitellarium; *yd. yd.*, yolk ducts; *yr.*, yolk reservoir.

„ 4. *Stephanochasmus ceylonicus*, n. sp. Ventral view of the living larva after liberation from cyst. (Drawn by JAMES HORNELL.) × 24.

ic., intestinal cœca; *ev.*, excretory vesicle; *ex. t.*, paired diverticula of the excretory vesicle; *os.*, oral sucker; *t.*, testes; *v.s.*, ventral sucker.

„ 5. Same. Lateral view of the anterior end. Leitz. Obj. 3, Oc. 3.

ic., intestinal cœca; *ph.*, pharynx; *pr.*, præpharynx; *vs.*, ventral sucker.

„ 6. Same. Ventral view of the oral sucker. Leitz. Obj. 5, Oc. 3.

„ 7. *Acanthocolpus liodorus*, n. gen., n. sp. Ventral view. × 30.

„ 8. Same. Lateral view. × 30.

„ 9. *Schistorchis carneus*, n. gen., n. sp. Ventral view of the living worm. Natural size. (Drawn by JAMES HORNELL.)

„ 11. Ventral view of another specimen somewhat squeezed and lying in creosote. × 6.

„ 12. Ventral view of a young specimen containing but a single egg in its uterus. × 10.

PLATE II.

Fig. 10. *Schistorchis carneus*. Ventral view of a specimen lying in alcohol. × 8.

„ 13. *Gastris consors*, n. gen., n. sp. Ventral view of an adult specimen lying in alcohol. × 8.

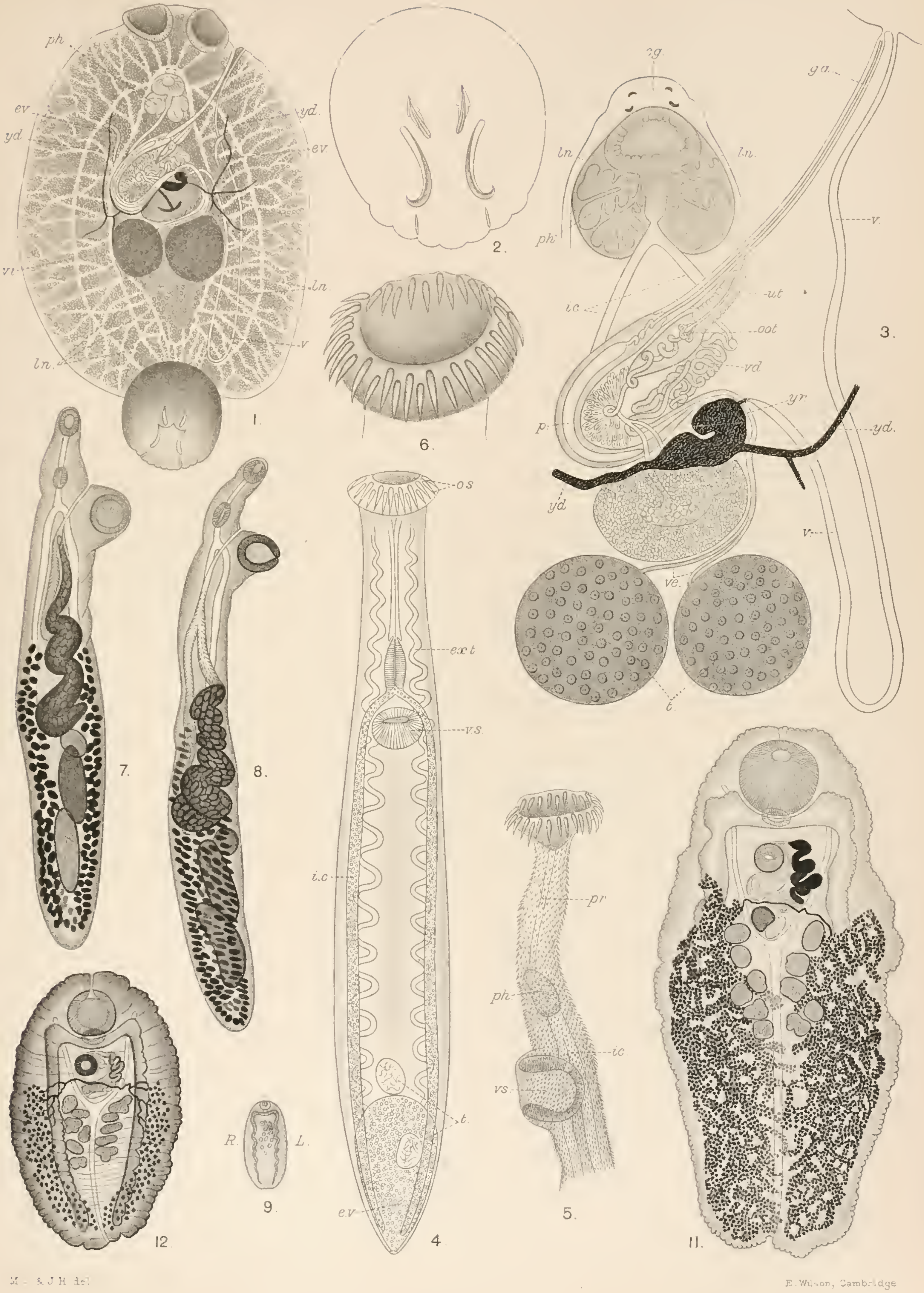
„ 14. Ventral view of another specimen somewhat squeezed and lying in creosote. × 10.

„ 15. Dorsal view of a third specimen squeezed in a similar manner. × 10.

„ 16. Ventral view of the fourth (young) specimen. × 20.

„ 17. *Anaporrhutum largum*, n. sp. Ventral view. × 12.

„ 18. *Distomum*, sp., from *Pinna*. Lateral view. × 38.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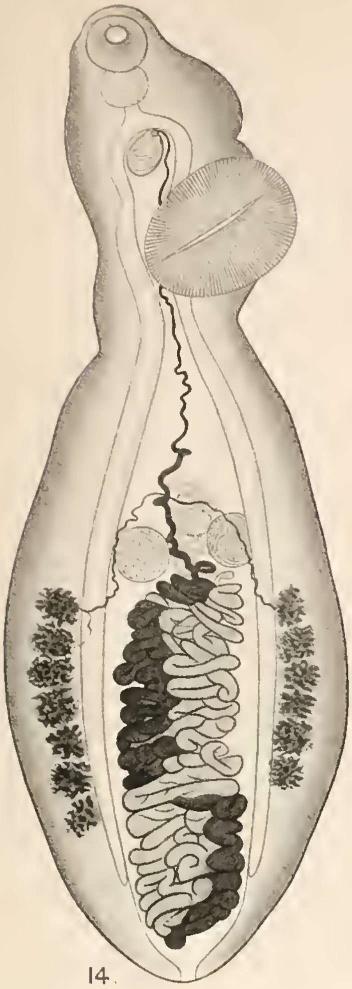
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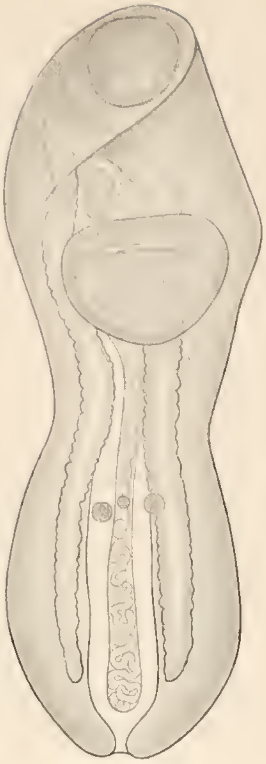
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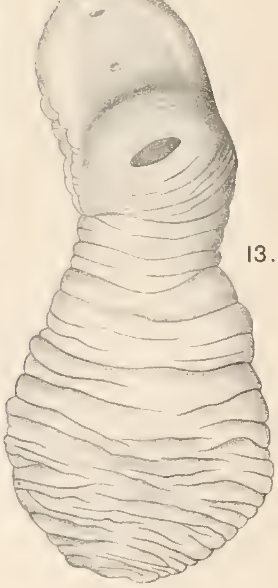
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GENERAL SUMMARY AND RECOMMENDATIONS.

As the results of this investigation, which has extended over four years and a half, are scattered through a number of articles in the five volumes of this Report, it seems desirable, now that the practical work is concluded, that I should give a summary account of the conclusions arrived at, and should bring together and revise the various recommendations made to the Ceylon Government from time to time. In doing so I shall omit all consideration of purely speciographic and faunistic results, as these matters will be dealt with in a separate article on Geographical Distribution at the end of the Supplementary Reports in this volume. I am here only concerned with those biological results which have a bearing upon the life-processes of the pearl oyster, the nature and characteristics of the "paars" and the prosperity of the Ceylon fisheries.

The observations upon which these conclusions are based were made :—

1. During the two cruises of the "Lady Havelock" in the Gulf of Manaar, and around Ceylon, during the spring of 1902.

2. During our subsequent work with the divers on the inspection ship "Rangasami-Poravi."

3. By Mr. Hornell at the Marine Biological Station, Galle, after I had left Ceylon.

4. During Mr. Hornell's various inspections, and the fisheries that have been held since 1902.

5. All of which observations have been corrected when necessary, and correlated where possible by the laboratory work in Liverpool upon the material sent home for investigation. In this laboratory work I have had the advantage of frequent help on special points from scientific friends in other Universities, and from some of my assistants in the Zoological Department of the University of Liverpool.

The factors which determine the problems of the life-history, prosperity and pearl-production of the Ceylon pearl oyster are so inter-related, that it is scarcely possible to make a consistent classification into mutually independent sections ; still, I think it may conduce to clearness and help the reader, by providing landmarks, if I group

the results under a few main headings. It will be readily seen that these overlap in places, that the groups are not all of the same value, and that it has not been possible to keep the "Summary of Conclusions" and the "Recommendations" strictly separated.

A.—SUMMARY OF CONCLUSIONS.

I. The Pearl Banks—the Physical Surroundings of the Pearl Oyster.

The pearl oyster, or rather "mussel" (*Margaritifera vulgaris*, Schum.) of the Ceylon fisheries lives in very pure and clean sea-water in the Gulf of Manaar on certain patches of hard ground known as "paars" (see charts and maps in Part I.). There is no strict line of demarcation between the paars and the neighbouring sea-bottom. We have evidence to show that the outlines, and the extent of the paars, may be altered from time to time by the weather. What is a hard patch one season may be covered by an overwash of sand in the next, and then again be swept clear by an exceptional storm or current. These changes, although they may occasionally cause damage to an oyster bed, are not wholly detrimental; they sometimes uncover fresh ground upon which young oysters may settle, and they cause us to recognise that the whole of the wide shelf within the 10-fathom line in the northern part of the Gulf of Manaar is potential paar-ground, and is susceptible of artificial improvement for purposes of cultivation.

The paars are, for the most part, at depths of 6 to 9 fathoms, and those that are best known as fishing grounds lie at a considerable distance from land, the Cheval Paar 9 to 14 miles, the Periya Paar Karai 12 miles, and the Modragams about 8 miles from the nearest coast.

The Muttuvaratu Paar, at about 4 miles off Karativu Island, is the only one where important fisheries have been held that is near the shore. In no cases have the pearl oysters been found between tide-marks, or contiguous to the beach, in the Gulf of Manaar, although it has been shown that they can live in such a position in the sheltered waters of Trincomalee. For further details as to the positions, depths, extent and other characters of the paars, see the sections on "Description of the Pearl Banks" in Part I., and on the "History of the Principal Pearl Banks" in Part II. of this Report.

The hard bottom of the paars is to some extent formed of corals and shells, but to a much larger extent by a modern rock now forming *in situ*. This has been called a "calcrete" (see "Report on the Sea-bottoms," by Mr. Lomas, in Part I., p. 147), as it is composed of the sand and neighbouring organic remains cemented into a continuous hard mass by carbonate of lime.

It has been shown in this Report that the cementing, although no doubt in part a chemical process, is in places a biological result, since it is largely due to the growth of living Nullipores and Polyzoa—especially the latter (see fig. 1).

When the bottom on the pearl banks is not calcrete, it is formed of a coarse sand, in some places almost wholly inorganic, containing large quartz grains, and derived from the waste of the granulitic rocks of Central Ceylon brought down by the rivers:

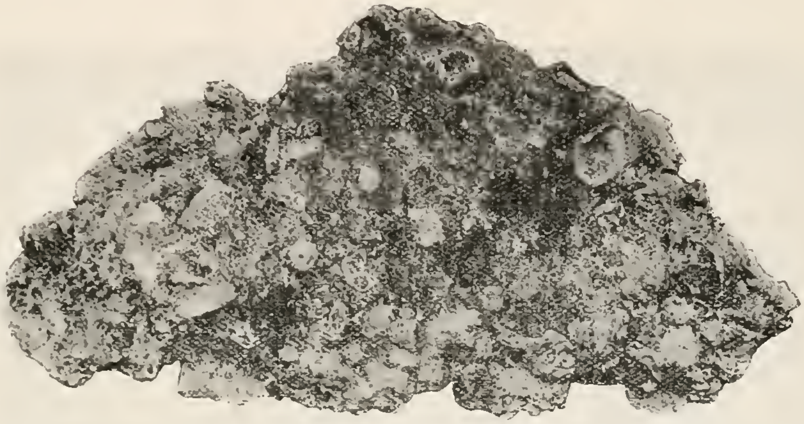


Fig. 1. Lump of calcrete showing large quartz grains and felspars with fragments of coral, shells and worm tubes, along with many Polyzoa colonies. From Jokkenpiddi Paar.

Elsewhere the sand is of organic origin, and is formed chiefly of the shells of large bottom-living Foraminifera, such as *Amphistegina lessonii*, *Alveolina melo*, *Heterostegina depressa* and *Orbitolites marginalis*, mixed with the calcareous remains of many other kinds of animals (see Report upon the Foraminifera in this volume). The divers distinguish between a hard bottom (the "paar") suitable for pearl oysters, and a sandy one which is more or less useless. The sand, however, in the neighbour-

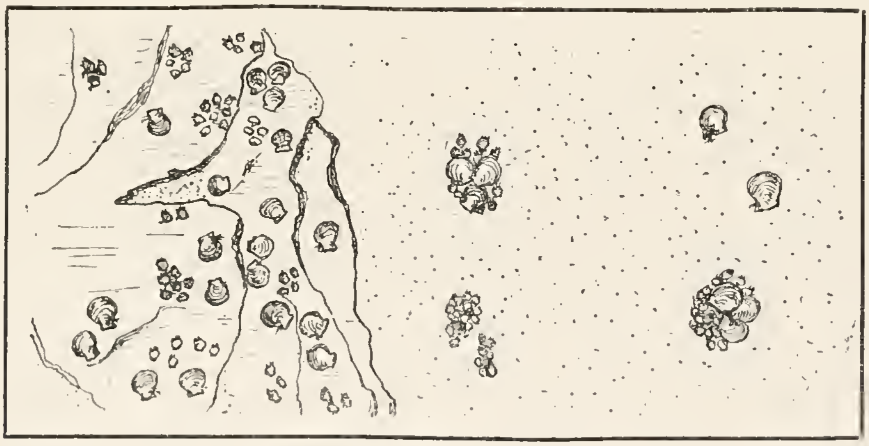


Fig. 2. Diagram showing the arrangement of pearl oysters (large and small) in clumps on the sand and singly attached to flat ledges of rock.

hood of paars often bears considerable numbers of oysters in clumps (fig. 2) adhering to fragments of dead coral, to old molluscan shells, or more frequently to nullipore nodules (*Lithothamnion fruticulosum*), see fig. 3.

Such pieces of natural cultch are of enormous importance to the prosperity of the

fisheries, and the area covered by these fragments and so made available for the attachment of pearl oysters, might be largely extended by artificial "cultching." Large areas of the important Cheval Paar, for example, would be improved by further cultching.

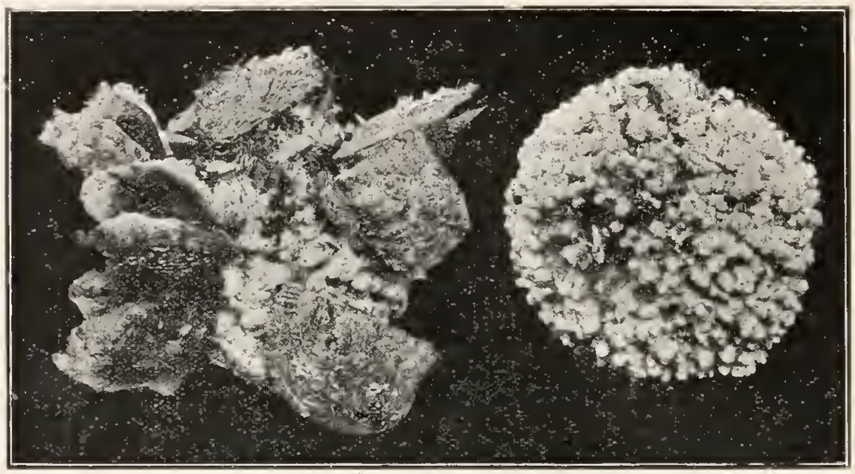


Fig. 3. Nullipore ball (*Lithothamnion fruticulosum*) with tags of byssus where pearl oysters have been attached (to the right), and a similar ball still covered with young pearl oysters (to the left); natural size.

The temperature of the sea-water in which the pearl oysters live in the Gulf of Manaar is high. In our experience in 1902 it ranged from about 77° F. in January to close on 90° F. in April. In February, 1904, the range was from 80° to 84°, in March from 81° to 86°, and in April from 84° to 88° F. In all cases the temperature was taken at a depth of 2 feet below the surface of the sea, at 7.30 A.M., noon, and 5.30 P.M. each day. Probably the normal range during the greater part of the year is from 82° F. to 86° F.

The specific gravity we found to be fairly constant at 1·023 on the pearl banks; at Galle it was slightly lower, averaging 1·022; at Trincomalee in the inner bay, and especially in Tampalakam, it was distinctly lower (1·015 to 1·019). At exceptional spots and seasons in the Gulf of Manaar we have found the specific gravity lower than the normal. Off Chilaw, in November, 1902, it was slightly above 1·019, and on the Muttuvaratu Paar in the same month it averaged about 1·020. No doubt on occasions of great floods on the land it may be lower still on those paars that are near the mouths of the rivers. There is no reason to think (as has sometimes been stated) that some admixture of fresh water is necessary for the prosperity of the oyster or for pearl-formation. On the contrary, exceptional floods are probably harmful to any paars they may reach. On the other hand, it is possible that the outflow from the great land-locked lagoons (*e.g.*, Portugai Bay and Dutch Bay) influence the sweep of the coastal currents and help to determine spat-falls on the neighbouring banks. The great tidal outflow from Dutch Bay probably influences deposition on

the Muttuvaratu Paar by breaking up the north or south current into local eddies. Similarly the South-east Cheval and Modragam Paars are within the influence of the outflow from Portugal Bay.

There is a general drift of the water over the banks from south to north between April and September, and from north to south during the height of the north-east monsoon, with intermediate periods of calms and variable winds from February to April, and usually again in November. But we are still in want of more definite information (such as can only be obtained by some years of observation and experiment with "drifters") in regard to the usual surface drift during the periods of variable winds between the monsoons, before we can be certain of the source of "spat" supply to particular banks, or of the destiny of larvæ produced from our adult oysters. "Drift-bottle" experiments, such as have been recently made for fisheries purposes in several European seas, should be instituted in the Gulf of Manaar. It is only after such work has been carried on systematically for two or three years at least that it will be possible to determine the course taken by the larval pearl oysters between the time of hatching and the deposition of spat, and again between the attachment to floating Algæ and the appearance of young oysters on a paar. These are details which it was impossible for us to determine in the time at our disposal in 1902, but which could be readily settled by the Marine Biologist if he were given the necessary facilities. Such information will obviously be of value whenever it becomes necessary to decide upon the best section of a bed of oysters to be reserved as a breeding stock.

II. Fauna and Flora—the Biological Surroundings of the Pearl Oyster.

The Fauna and Flora of the Gulf of Manaar, comprising the whole assemblage of plants and the other animals, large and small, which surround the pearl oyster, have a profound effect upon the well-being of the stock upon the beds, and hence upon the prosperity of the fisheries. We have taken every opportunity of investigating this fauna and flora; and the results of our collecting are reported upon in detail by specialists, in the series of Supplementary Reports given in these volumes. It will suffice to point out here, that the microscopic forms floating in the water and captured by our fine silk tow-nets included (1) the pearl oyster itself in its youngest free-swimming stages, (2) its food, not merely when young, but throughout life, and (3) young stages of the parasitic worms which infest the oysters and some of which induce pearl-formation; and that the larger animals on the sea-bottom—sponges, corals, starfish, molluscs, crustaceans, and fishes—are the all-important enemies or fellow-competitors of the oyster (for food and attachment areas and growing room), which may ruin a promising bed either by their direct aggressive action or indirectly in the struggle for existence.

It is impossible, until a careful study has been made of each case, to say which members of the fauna and flora of an oyster bed are of most importance to its

prosperity—probably none are wholly without influence for good or evil, so closely interwoven in past history and present function is the web of living nature.

III. Reproduction and Life-History of the Pearl Oyster.

We find that the Ceylon pearl oyster is diœcious, or has the sexes separate, not only at any one period, but throughout the life of the animal. Our observations on innumerable microscopic sections of preserved material, and Mr. Hornell's experiments at Galle (see Part I., p. 125), have shown that quite definitely; and there are no traces of hermaphroditism. Emission of the generative products takes place directly into the surrounding water, where the ova are fertilised, and consequently there is no retention of eggs or embryos within the body of the female. The male is stimulated to emit spermatozoa by the presence of ova in the surrounding water, and as the animals are gregarious, and males and females are found mature together, it becomes practically certain that all eggs will be fertilised under normal conditions.

There is no marked disproportion in numbers between the sexes; out of a couple of hundred collected together at random and examined in 1902, 87 were males, 71 females, and the remainder immature or indeterminate. Similar observations made on several occasions since have given us much the same results.

Reproduction appears to take place to some extent throughout the year, and stray individuals may be found to be sexually ripe in any month; but there are two maxima when the majority of the pearl oysters in the Gulf of Manaar become mature and shed their reproductive elements, viz., in mid-summer from May to July and in mid-winter from November to January. It must be remembered that the temperature and other conditions in these two periods of the year do not differ very greatly. The one period is during the prevalence of the south-west monsoon and the other during the north-east. Hence the importance of ascertaining precisely the resulting currents that would carry floating embryos as the result of the prevailing winds at each such period is obvious. It will be noted that these statements are only made in regard to the pearl oyster in the Gulf of Manaar. It may well be that even the same species in other localities, such as the Persian Gulf or the Red Sea, has other breeding habits.

Larval development takes place in the surface waters of the sea, and from our observations we draw the conclusion that the young animal may settle down as "spat" within 5 days of the fertilisation of the egg. At the same time, from the size of some of the larvæ we have found, we consider it probable that the free-swimming period may on occasions be considerably prolonged. We were able to rear young larval stages in the Galle Marine Biological Station, and we caught the later ones in the tow-nets on the pearl banks. We found the youngest fixed spat on Zoophytes and Algæ early in November and early in March. All fixed stages, from one similar to the latest of the free stages up to young oysters having the adult characteristics of

shell, were found during March and April, 1902, attached to both rooted and floating Algæ in various parts of the Gulf of Manaar. The so-called "false-spat" (other smaller allied shell-fish, such as species of *Avicula*) also occurs on Zoophytes and Algæ; but during the time of our investigations there was undoubtedly abundance of the true pearl-oyster spat both on filamentous green and red Algæ from the bottom (Plate, figs. 32, 33), and also on floating *Sargassum* weed (fig. 4). The importance of these Algæ in thus affording attachment to the youngest stage of the spat, and in afterwards distributing it widely, can scarcely be over-estimated (for the names of the species of Algæ involved, see 'Report on the Algæ,' Part I., p. 163).

Fig. 4. Sketch of young pearl-oyster spat attached to *Sargassum*.

Mr. Hornell has been unable, since he became Inspector of the Pearl Banks, to obtain, during the anxious and busy periods of successive inspections and fisheries, the amount of free time necessary in order to make detailed observations on the embryonic development; but we give here a brief outline, illustrated by a series of figures (see Plate), most of which he made in the summer of 1902 from embryos reared at the Galle Biological Station. Figs. 1 and 2 show the living egg on extrusion to be provided at one end with a micropyle through which fertilisation takes place, and which may be prolonged (fig. 1) as a slender tube. Figs. 3 and 4 represent the mature ovarian egg, fixed and stained as we now find it in our sections, and showing a well-marked nucleolus lying in a clear vacuole. The egg shown in fig. 4 measured about 0·05 millim. along its greater axis. Fig. 5 gives the outline of the spermatozoon much more highly magnified than the ova.

The segmentation is complete, but unequal, and the stages seen in figs. 6, 7, and 8 agree with those we are familiar with in some other allied molluscs. The enclosure of the larger macromeres by the smaller micromeres, seen in progress in figs. 7 and 8, is shown far advanced in 9 and completed in 11. The single macromere of fig. 8 has divided into two in 9 (see optical section 10) and into four in 11 (see optical section 12). Fig. 11 shows the flattening of the lower, posterior, end and the first appearance of a zonal (præ-oral) band of cilia round the widest part of the body. This is a young trochophore stage, and completed trochophores are seen in figs. 13 (22 hours), 14 and 15 (26 hours), and 16 (30 hours after fertilisation). These stages show an enteron opening to the exterior near the posterior end, a posterior patch of cilia, a long anterior tuft on the prostomium, and an equatorial præ-oral circlet of cilia (see fig. 15).

After this stage our series is not so complete, but we give such stages as we have of later larvæ, as they may be useful to future observers for comparison with forms captured in the tow-net. Fig. 17 shows a couple of unfertilised eggs, not yet beginning to decay or disintegrate, at three days after extrusion from the parent. Fig. 18 shows the first appearance of the larval shell, three days after fertilisation; and figs. 19, 20, and 21 show three pelagic (also shown in text-fig. 5), but shelled, forms. The ciliated velum (*a*), the adductor muscles, the mobile foot, the otocyst, a pigmented eye-spot, the developing gill filaments, &c., are readily seen.

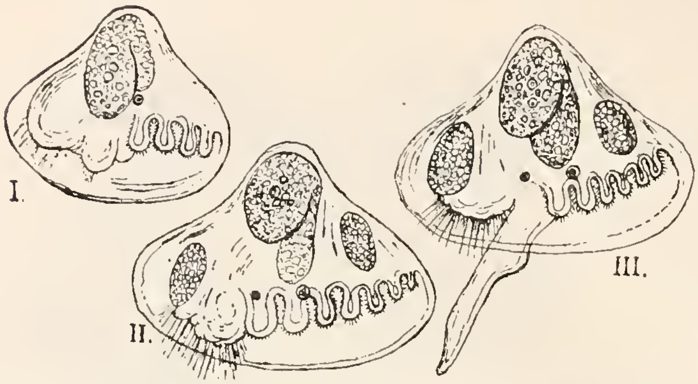


Fig. 5. Free-swimming larval stages of pearl oyster caught in the tow-net. I. has the ciliated velum retracted. II. and III. show the stage at which the larva becomes attached to Algæ. III. has the mobile foot extended.

The larva is now at a stage when it is ready to affix itself to some foreign body (Plate, fig. 32), such as the filamentous green Algæ. Figs. 22 to 27 (and also text-fig. 6) show young stages of growth of the shell after fixation. Fig. 22, the youngest fixed form we have found adhering to Algæ, measures 0·4 millim. in greatest extent, and is identical with fig. 21, the latest free-swimming stage we have found. Fig. 23 shows that the new growth added to the shell ("prodissoconch") of the "spat" after fixation is formed of prismatic substance, and is entirely different in appearance from the structureless embryonic shell marked only by concentric lines of growth. Fig. 31 shows the junction of these two layers of the shell, and also the free margin, magnified, at this stage. Further additions of prismatic substance which is gradually surrounding the embryonic shell are shown in figs. 24 and 25. The byssal sinus, indicating the anterior end of the shell, appears in these stages. In the next (fig. 26) it has worked its way further dorsally. Developing gill filaments are present in all these stages, seen through the thin shell of the "spat." In fig. 26 the filaments have become long and slender, and are about 10 in number. The spat is now 1 millim.

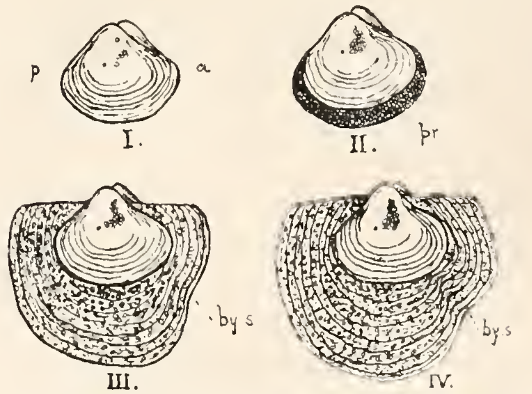


Fig. 6. Stages in the growth of the shell after the attachment of the larva. I. is identical with the latest free-swimming stage; *a*, anterior, *p*, posterior end. II. shows the first formation of prismatic shell (*pr.*). III. and IV. show the change in shape and the byssal sinus (*by.s.*).

across, and three regions are distinctly visible in the shell, the structureless, clear, embryonic shell or prodissoconch marked by very regular and delicate lines of growth, and forming the hinge (with 5 anterior and 5 posterior teeth, separated by a slight median interspace, figs. 28, 29, on each valve) and the umbo; the now very extensive prismatic part extending to the free margin all round and having very much the shape of the adult; and finally an intermediate region which in addition to the prismatic part has a lining of nacre. These three regions of the shell are still seen in fig. 27, but the prodissoconch is now becoming imbedded in the later formed shell and so loses its distinctness; its umbo, however, is still prominent. This specimen, which measures 1·5 millims. in diameter, is seen from the left side; the preceding figures were seen from the right. In fig. 27 pigment has commenced to form in the prismatic layer, producing 4 to 6 yellow or ruddy-brown radial bands, most marked at the periphery and dying away internally. These and still larger young oysters are shown in fig. 33, natural size, attached to an Alga; while a sample of "false spat" is shown in fig. 34, and enlarged in fig. 30 (*Avicula vexillum*, REEVE).

The spat in all these stages of growth is very actively locomotive. Although it can fix itself by the byssus threads, it does not usually remain fixed for long. When moving, it pulls itself along by means of the large mobile foot (see fig. 7). We have many observations showing the rapidity with which it can detach and re-attach itself, and the rate at which it can travel (see Part I., p. 68). There is no doubt, then, that in this young stage the pearl oyster can leave the weed to which it first becomes fixed and transfer its attachment to a coral or nullipore fragment on the paar, or can move from an unsuitable spot in search of a better. Its tendency to climb upwards whenever shaken on to the floor of an aquarium (see "Narrative," Part I., p. 69) is probably an indication of an instinct to ascend any solid objects on the sea-bottom, which must often save it from being smothered in the loose sand.

Fig. 7.

Our experiments on the pearl banks in 1902, and at the Galle laboratory, have shown that not only the young but also the adult pearl oyster is able to cast off its old attachment, move to a new place, and there spin a new byssus, and this not once or twice, but repeatedly, up to eight times in fourteen days, as our records show (see fig. 8).

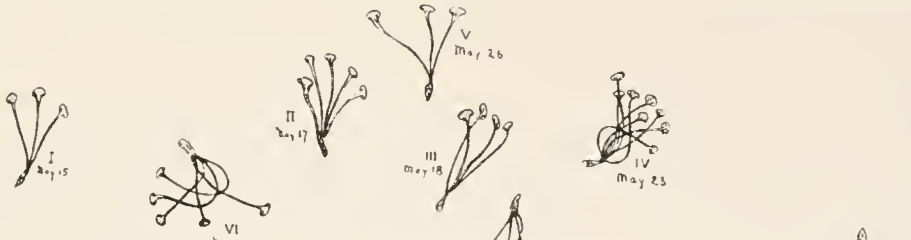


Fig. 8. Diagram showing the eight successive positions in which a pearl oyster formed new byssus strands in a fortnight. One half natural size.

We do not mean to assert that the oysters have a power of locomotion that would enable them to migrate to any great distance; but our observations have convinced us that they have powers of freeing themselves from sand, of moving to a better position, of re-attaching themselves when torn off from their moorings, and of repairing injuries to shell and mantle (for details see section 'Observations and Experiments,' &c., Part I., p. 125), with which they are not usually credited.* All these field and laboratory observations, it is scarcely necessary to point out, have an important bearing upon some of the practical recommendations that follow (p. 133).

IV. Practical Considerations.

Many of our observations and experiments were made with the view of gaining information as to the practicability of transplanting the pearl oysters from one locality to another. We have shown that the transportation of oysters, both old and young, even for considerable distances—such as from the head of the Gulf of Manaar to Galle, a matter of four or five days—at the hottest season of the year, is comparatively easy if ordinary precautions be taken to keep the water in the vessels as cool as possible and to prevent any decomposition taking place. Transplanted specimens, moreover, flourished in our hands. Both at Galle and in the Gulf of Manaar (where some batches were moved from the Muttuvaratu Paar to the Cheval) the oysters improved in health and grew rapidly in size when moved to a new locality. We have given the details of growth for both old and young oysters in preceding sections of this Report (see Part I., p. 136). These and other experiments were all undertaken because of their bearing upon that transplantation, in quantity, from overcrowded and unreliable paars to more suitable ground, which we have advocated throughout this Report.

Some of our experiments gave us a clear indication, which, however, we also obtained from observations on the pearl banks, of the kinds of foreign objects best suited for young pearl oysters to settle down upon, and also of the objects, such as living coral, to which they cannot become attached. This, then, led us to recognise the value of natural "cultch," or suitable hard objects, such as dead coral fragments, old shells and nullipores, upon the bottom, and the importance of increasing the area available for beds by the artificial "cultching" of the more sandy parts of the paar-ground.

We must not try to be too precise in regard to the positions, sizes and outlines of the paars. Our work in the "Lady Havelock" showed us that some spots around and between them are more or less hard-bottomed, and even, in some cases, bear oysters, and are evidently capable of becoming fishable paars. On the other hand, it is clear from the record of the inspections that many parts of the known paars may be

* Although Kelaart observed certain powers of locomotion and of byssus regeneration nearly fifty years ago; and more recently H. Sullivan Thomas (1884) made similar observations.

temporarily, and possibly some parts even permanently, unsuitable for the attachment and rearing of oysters.

We may consider, then, the whole pearl-bank plateau of the Gulf of Manaar as potentially paar-ground, some parts of it better suited for one purpose and some for another, some parts more constantly covered by the shifting sands, others more regularly bare and hard. It is this condition that gives man his opportunity and renders possible the farming operations, such as cultching and transplanting, which we urge in our Recommendations.

The history of the pearl fisheries in the past, especially during the nineteenth century (see Part II., p. 1), has shown that :—

1st. A number of the smaller paars, which are hard patches of limited extent largely covered with living corals, are practically worthless from an economic point of view.

2nd. Some parts, such as the Periya Paar, might be used as most valuable sources of supply of young brood oysters for transplantation, but cannot be relied upon to produce an adult stock suitable for fishing.

3rd. Others again, such as the great Cheval Paar with its various subdivisions, and the North and South Modragams, the Periya Paar Karai, and the Muttuvaratu Paar, are very valuable and fairly reliable grounds, upon which most of the successful fisheries of the past century have taken place. Others, such as Chilaw, Dutch Modragam, Alantura and Karativu, are less reliable, but may be valuable on occasions, and are also of importance as sources of spat-production available for transplantation.

It became clear to us during our work on the "Lady Havelock" in 1902—when we understood why it is that the Periya Paar is unreliable and the Cheval Paar so much more satisfactory—that the main hope of introducing some constancy of result and a more regular succession of fisheries must rest upon a system of transplanting young "strikes" or broods of oysters, whenever they make their appearance upon useless or unreliable paars, to wherever there is room for them at the time upon ground that is more certain to give them a better chance of living and growing to maturity.

Speaking generally, the Cheval appears to be the most reliable of these areas, and more especially its south, south-east, and mid-east sections. Whenever possible, the brood oysters, to replenish the Cheval Paar, should be brought from the Periya Paar, which is most suitable by reason of its proximity, the frequent spat falls thereon, and the impossibility of such spat growing to maturity on its own area. Next to the Periya Paar the most suitable grounds from which to obtain spat are the many small paars off Chilaw. Like the Periya Paar, these paars seldom bring their oysters to a fishable age, and when they do, the numbers and value are comparatively insignificant. But in the economy of the banks they have importance as sources whence the Cheval may be replenished. They should be utilised whenever the Periya Paar is not

available; and even when brood oysters on the latter are to be had, it may be preferable to go to the Chilaw banks for the supply if the oysters thereon are older. If year-old oysters can be had on the Chilaw beds in quantity, while those on the Periya Paar are only three months old, then it is best to move the older, Chilaw, oysters first, since they have already survived the critical first year of life, and are probably worth three times their number of the younger brood.

The transplantation system can be extended also to older oysters. We have shown that even adults can throw off the old byssus and form a new attachment-cable whenever necessary. Consequently, overcrowding or any other source of danger should now be mitigated whenever possible by transplanting to unoccupied ground on the more favourable paars.

V. Causes of Disaster.

The above-mentioned points raise the whole question of the causes of death in the pearl oyster, the reasons of the intermittence in the history of the fisheries, and the conditions which render some paars more reliable than others. These matters have been discussed in various preceding sections of this Report (see especially Part I., p. 120, Part II., p. 35, and Part III., p. 25)

The following gives a summary of our results:—

(I.) The most important agent in causing wide-spread death of pearl oysters—both young and old—in the Gulf of Manaar is the shifting of sand due to the strong currents prevalent during the south-west monsoon, and no doubt occasionally (but rarely) to exceptional storms. We obtained a good deal of evidence as to the manner in which the sand is carried about and piled up by the currents, and is churned up in places by the swell of a strong south-west monsoon, and we made observations as to the effect of burying oysters of different sizes in various amounts of sand. The successive broods of young oysters which have appeared, and as regularly disappeared, upon the Periya Paar during the last quarter century have, there can be no doubt, been overwhelmed by the bottom currents caused by the south-west monsoon upon that bank which lies furthest from land and faces the deep water of the Indian Ocean. The destruction from this cause is enormous. In March, 1902, we ran a line of observations along more than six miles of the length of the Periya Paar, and estimated that the bank bore at that time not less than about a hundred thousand millions of young oysters. When Mr. Hornell returned the following November, he searched the ground from end to end and found only a few dead shells. In November, 1904, this paar was again found to be covered with millions of young oysters, but a year later not a single survivor was left. On the Periya Paar this colossal destruction is probably an annual occurrence. On certain other less exposed paars it happens occasionally, and loss to a minor extent from overwashes of sand may occur almost anywhere under exceptional circumstances. For example, the

disappearance, from the Muttuvaratu Paar, of 72 million oysters, one year old in 1897, before 1899 was probably due to this cause; and also the sweeping away, by an exceptionally strong current, of the oysters on the north end of the East Cheval Paar between November, 1887, and February, 1888.

(II.) Next in importance come, we consider, the ravages of natural enemies, the most noteworthy of which are:—

(*a*) Voracious fishes, chiefly rays (*Rhinoptera javanica* and other allied species) and file-fishes (*Balistes mitis*, *B. stellatus*, &c.).

(*b*) Boring Gastropod Mollusca, chiefly *Sistrum spectrum* and *Pinaxia coronata*, along with species of *Nassa*, *Murex*, *Purpura*, and *Turbinella*.

(*c*) Boring Sponges (*Cliona margaritiferæ*).

(*d*) Boring worms (*Polydora hornelli*).

(*e*) Starfishes, chiefly *Pentaceros lincki*, *P. nodosus*, and *Luidea maculata*.

(*f*) Smothering Lamellibranch Mollusca, such as *Modiola barbata*, the "Suran," which weaves nests and other entanglements around masses of young oysters, and may, when present in quantity, cause serious mortality.

(*g*) Crabs and cuttle fishes, and possibly other animals also, which can tear off the byssus and crush the shell.

(*h*) Associated animals, such as Corals, Barnacles, and Sponges, adhering to the shell, which, mechanically or by competition for food, cause injury and even death.

A few of these natural enemies call for some further remarks.

The file-fishes (several species of *Balistes*) and also the "Vellamin" (*Lethrinus*, spp.) feed upon immature oysters. We have found the broken shells in the stomach; but although these fish frequently snip pieces out of the margins of quite large shells, they probably do not destroy adult thick-shelled oysters. Shells which are rendered rotten by the borings of the sponge *Cliona* fall an easier prey to all oyster-eating fish.

Fig. 9. Fragment of pearl-oyster shell crushed by the teeth of a large Ray.

The larger Elasmobranchs, such as the Eagle-Rays, and allied forms, may cause very serious reduction in a bed of mature oysters. In 1903 Mr. HORNELL found large rays feeding on the Periya Paar Karai, and, on exploring the bottom in a diver's dress, obtained abundance of the crushed shells left by the rays. Shells broken up by these fish have a peculiarly cracked and splintered appearance, which is characteristic (see fig. 9), the fragments of the brittle nacre being held together by the tougher prismatic margin.

In regard to these various fish enemies of the oyster it is necessary to bear in

mind that, from the pearl-fisheries point of view, their influence is not wholly evil, as their ravages are closely associated with pearl-production. Although these fishes doubtless devour many of the oysters, at the same time they receive and pass on the parasite which leads to the production of pearls in others. One of the largest and most voracious of rays, *Rhinoptera javanica*, the "Valvadi tirikkai" or gregarious ray of the divers, we have found to be the host of the adult *Tetrarhynchus unionifactor*, which in its larval stages causes pearl-production in the oyster. The loss of some individuals from a bed is in that case a toll that we may willingly pay, and no one could advocate the extermination of that particular enemy, although we may desire to restrain his ravages within limits. During the fishery of 1889, the gregarious ray was present in such abundance that about 7,000 were caught in a single haul of a net, near Dutch Bay (see this vol., p. 61).

The Mollusca, which bore into shells by means of their radula, a toothed band lying in the floor of the mouth, are for the most part small Gastropods, and they are collectively known as "uri" by the divers. Fig. 10 shows a group of "uri" such as we have frequently caught in the act of penetrating the valve of a pearl oyster. It is chiefly young shells that are attacked, and amongst a large number of dead valves, about an inch in diameter, examined on one occasion, we found 60 per cent. were perforated by the neat circular hole which clearly indicated the cause of death. Probably adult pearl oysters are rarely killed by these small enemies.

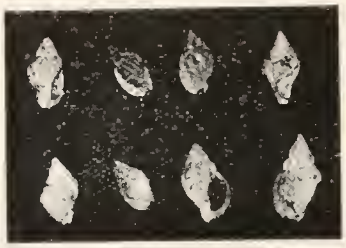


Fig. 10. "Uri," small Gastropods that destroy young pearl oysters by boring through the shells and sucking out the soft body.

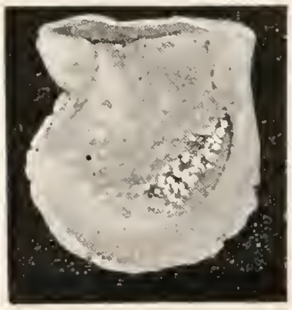


Fig. 11. Inside of pearl-oyster shell, showing adductor impression affected by *Cliona* borings on the outside. × ½.

During our work on the pearl banks we have not found a single full-grown shell perforated by a Gastropod. If such do occur, the enemy cannot be the small "uri" figured above, but must be more powerful animals, such as the larger species of *Murex* and the Chanks *Turbinella pyrum* and *Fasciolaria trapezoides*.

The boring Sponge, *Cliona margaritifera*, Dendy (see Part III., p. 128), may be considered damaging from two points of view—first, as causing thickened deposits of nacre and other irregularities, and hence disturbance of function, at the attachment of the great adductor muscle (see fig. 11); and secondly, as honeycombing the shell

in all directions, rendering it so rotten that it can no longer hold together, and so falls an easy prey to any assailant. Many pearl oysters have their valves penetrated by *Cliona* to some extent, and in some beds a considerable proportion are as much affected as the example shown in fig. 12. This is a disease of adult life. Young shells never contain *Cliona*, and the older the affected oyster is the worse does it get. It will be noticed that the ravages of this sponge have a bearing on pearl formation. The more friable shells are eaten more readily by the voracious fishes, and consequently *Cliona margaritiferæ* may be regarded as facilitating the transference of the pearl-inducing parasite from the oyster to its ultimate host.

Fig. 12. Pearl-oyster shell honeycombed by *Cliona margaritiferæ*, DENDY.

Another boring enemy is the small Polychæte worm *Polydora* (or *Leucodore*) *hornelli*. It is questionable, however, whether this really does serious harm, except indirectly, in the case of the Ceylon pearl oyster. It no doubt, by its burrows between the layers of the shell, helps in disintegration; it lets in mud and sand-grains, and it is sometimes the cause of nacreous thickenings or blisters in the interior. It is not, however, of anything like the same importance as *Cliona* and the Gastropods, and cannot, taken by itself, be considered a cause of death. A few other organisms, lamellibranchs, worms, algæ, &c., bore in the pearl oyster's shell —which is sometimes a veritable microcosm containing representatives of nearly every group of the Invertebrata—but none of them do serious harm, and they need not be considered further.

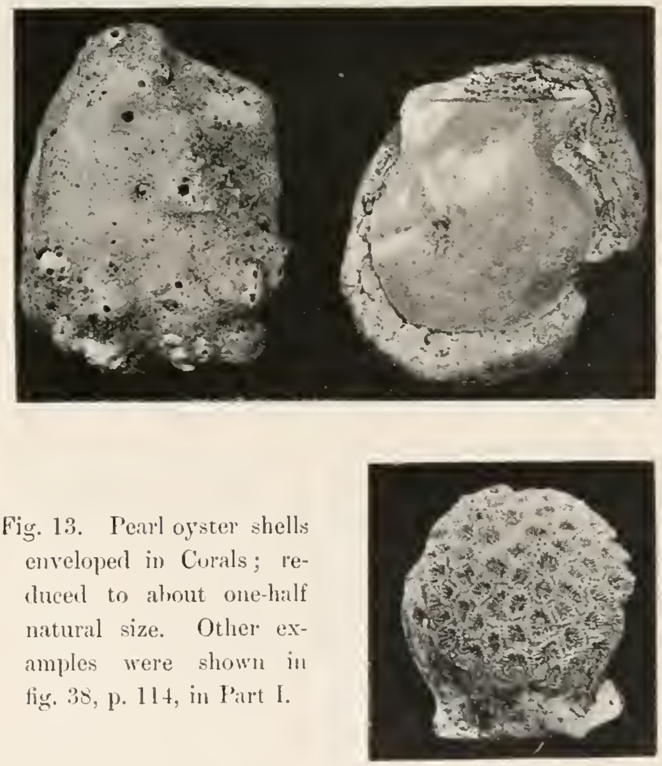


Fig. 13. Pearl oyster shells enveloped in Corals; reduced to about one-half natural size. Other examples were shown in fig. 38, p. 114, in Part I.

Similarly, the associated animals on the outside of the shell in most cases cause

inconvenience rather than real injury. There are only two classes of cases where the matter may become more serious, (1) where rapidly growing corals and sponges of large size settle on the shell and practically envelop it (figs. 13 and 14) or overweight it to such an extent as to interfere with the movements and nutrition of the oyster; and (2) where the acorn-barnacles (*Balanus amphitrite*, and other species) spread, as they sometimes do, all over the shells, and are so large and active as to compete successfully for the microscopic food in the water and so lead to enfeeblement and, it may be, diseased conditions in the pearl oysters. Young barnacles in the Ceylon seas appear to settle down in April or May, and then grow with astounding rapidity, so that in a few weeks, rocks, shells, boats, stakes, ropes and any other objects in the water become covered with an almost continuous layer. The living corals on the surface of the shells may also act by depriving their host of food, and we certainly find that the Ceylon pearl oyster cannot exist on the living coral reefs or where there is much live coral scattered over the bottom.

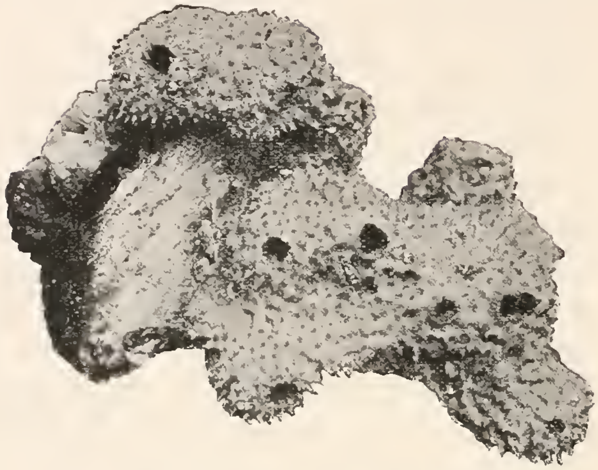


Fig. 14. Pearl oyster enveloped in a Sponge (*Pachychalina spinilamella*, Dendy).

The action of the little "smothering" mussel (fig. 15) called "Suran" by the divers is also, probably, partly mechanical and partly of the nature of competition for food. It weaves its tough byssal threads round neighbouring stones and dead and living oyster shells, entangling all in a matted mass in which it alone appears to flourish. It is, however, small and can have no effect upon adult oysters. It can only, then, do harm when it gets in large quantities amongst a bed of young oysters of its own size, and forms a blanket over and around them, interfering with respiration and nutrition. But it is very rarely sufficiently abundant, in Ceylon waters, to cause serious injury.

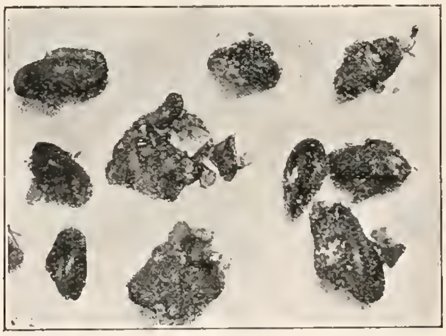


Fig. 15. "Suran," the small mussel (*Modiola barbata*) that entangles stones and small pearl oysters in its byssus; natural size.

Octopod cuttle fishes (such as *Polypus herdmani*) are abundant on some parts of the banks and are well known to subsist on oysters and mussels. Crabs are also numerous and no doubt cause some destruction; and there may be other members of the associated fauna that play their part in decimating the oyster beds.

Lastly, starfishes are probably the most serious of all invertebrate enemies. They are present in very large numbers on some parts of the pearl banks. We have a record that during the 1905 fishery, when the s.s. "Violet" was dredging for oysters on the South Modragam Paar, between 200 and 300 specimens of *Pentaceros lincki* and *P. nodosus* were brought up and destroyed each day.

Further, we know these starfishes to be exceedingly voracious, tenacious of life, active and fatal in their attacks on shell-fish. They seem to migrate from place to place in search of food, and are found to congregate round the rich feeding ground presented by a new oyster bed. One of the commonest kinds of the larger starfishes is *Pentaceros lincki* (fig. 16), known locally as the "Kondatchi Star," from its

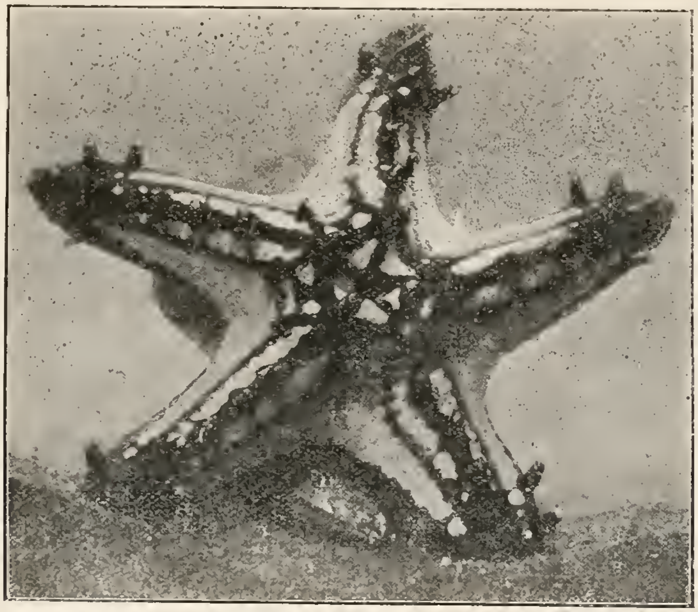


Fig. 16. *Pentaceros lincki*, DE BL., lying on a large pearl oyster, half natural size.

abundance on that paar. When we examined this bank in March, 1902, it had a bed of pearl oysters estimated at $5\frac{3}{4}$ millions. These had all gone by March, 1903, and it is probable that their disappearance may be accounted for by the very large number of starfishes present at that time.

(III.) There are still three other causes of death in pearl oysters that require mention, and may on occasion be serious, perhaps disastrous, *viz.* :—

(*a*) *Overcrowding.*—The older oysters are sometimes buried in masses of younger ones. The young are often piled together in such profusion as to interfere with each other's nutrition and growth. Thinning out must—and does—take place. If we don't do it, Nature does it for us. If it were done artificially, by transplanting some, all or nearly all might be preserved; if we leave it to be effected naturally by survival of the fittest, the survivors may be very few indeed.

(*b*) *Disease*, due to the invasion of parasites, either (1) worm parasites which are

moderately large and usually not very numerous, and which, unless abnormally abundant, probably do little or no harm; or (2) the more minute and more deadly protozoon parasites, such as sporozoa, which may on occasion be present in enormous quantities, and probably cause epidemic diseases. We have in various cases found sporozoa in the tissues of the pearl oyster. We also know that a bed of adult oysters may get into bad condition, the individuals becoming thin, discoloured and feeble; and under such circumstances rapid decimation takes place, and the bed, although not yet arrived at old age, may be practically wiped out by what is clearly a parasitic disease. It is highly probable that such diseased conditions are, if not the result of, at least generally concomitant with, overcrowding. For example, the Muttuvaratu Paar seems especially liable to dense deposits of spat, leading to overcrowding; and in our experience the oysters are more diseased and stunted and feeble on that paar than anywhere else.

(c) *Over-fishing.*—This is the exhaustion of the breeding stock of the district at a time when no further supplies of young in the larval stages are being brought by currents from neighbouring grounds. That, however, will comparatively rarely happen, and is only likely to be serious during the last year of a series of fisheries. So long as there are oysters in their second or third years on adjoining paars, which will be fished in the two succeeding years, it is safe—so far as the reproduction of the race is concerned—to take every older oyster that can be got from the ground, as those coming on, although not yet ready to be fished, are sexually mature, and may be relied upon to supply spat. But in the final year of a series of fisheries, when no further mature oysters remain for the following years, it is important to leave sufficient stock for breeding purposes. The complete clearing of the ground, which has sometimes been put forward as the ideal to aim at in a fishery, may be a short-sighted and disastrous policy.

In the future, however, if transplanting on an adequate scale is adopted, it may be expected that such a state of affairs as the last fishery of a series with no younger oysters growing up in the neighbourhood will be very unlikely to occur. Each individual case must, however, be considered on its merits, and the Marine Biologist, after an inspection of the banks, should be able to advise how the maintenance of adequate breeding reserves of adult oysters may best be secured.

VI. The Production of Pearls.

As pearl-formation is discussed very fully in another section of the present volume, it is unnecessary here to do more than add a very few sentences for the sake of completing this summary of results. In the Ceylon oyster there are several distinct causes which lead to this unhealthy or abnormal process, the production of pearls. Some pearls or pearly excrescences on the interior of the shell are due to the irritation

caused by boring sponges and burrowing worms. Minute grains of sand and other foreign particles gaining access to the body inside the shell, which are popularly supposed to form the nuclei of pearls, only do so, in our experience, under exceptional circumstances. In the whole of our observations we have only records of three cases in which a grain of sand undoubtedly formed the nucleus of a pearl.

Pearls of another class are found in the muscular tissue of the animal, most frequently in the levators, in the palpar region, and in the pallial insertions. These muscle pearls have no visible foreign bodies as nuclei. They form around minute calcareous concretions—the calcospherules—which are sometimes very abundant in the tissues. Yet the pearls are very irregularly distributed. Single oysters have been known to contain from one to two hundred pearls, and, on the other hand, a hundred oysters may be opened without finding a single pearl.

The best pearls, however, the "fine" or "orient" pearls, lie in the pallial connective tissue at the sides of the body or in the tissues around the liver and kidney, or, when large, they may be free in any cavity of the body. The majority of these fine pearls contain as their nuclei the more or less easily recognisable remains of certain Platyhelminthian parasites, which we identify as the larval condition of Cestodes belonging to the genus *Tetrarhynchus*. The evidence for this will be found in the section dealing with pearl-formation (this vol., p. 19), and a description of the probable species of *Tetrarhynchus* in question will be found in SHIPLEY and HORNELL'S report on the parasites (p. 87). We have traced most stages in the life-history of this pearl-producing *Tetrarhynchus*, and find that it passes, in the adult condition, into the body of one of the larger carnivorous fishes—*Rhinoptera javanica*, a Ray. The adult parasitic worm in its last host must then set free its numerous young embryos, which pass into the sea and so gain access to the gills, liver, and mantle of the pearl oyster. But it is not sufficient for the oyster to be infected by the *Tetrarhynchus* larva. It must also live, retaining its parasite until such time as it can produce sufficient deposit of the calcareous secretion to entomb the living source of irritation, which thus becomes the nucleus of a pearl. This history is discussed more fully in another section of this volume (p. 14).

The Cysticercoid cysts of the *Tetrarhynchus* larvæ are frequently very abundant in the liver of the pearl oyster. In the case of some paars, the Muttuvaratu especially, scarcely any of the individuals examined are free; we have counted eleven encysted larvæ in a single liver. In the gill filaments and in their membranous bases also they are common, while in many cases the mantle is infested. The gonads, the foot and the palps all occasionally harbour the parasite. The muscles are the only large organs where the cysts are rarely found. In one individual oyster Mr. HORNELL made out a total of 45 cysts for all the tissues. It may be well to repeat here that the Cestode parasites are not only common, but are also apparently very wide spread and generally distributed, and that the fish-host with its parasite occurs also generally in the seas around the Island, as well as in the Gulf of Manaar; and that, in short,

there can be no doubt as to the probable infection of pearl oysters grown at any other suitable localities around Ceylon

Pearl production in the Ceylon oyster does not commence actively until the third year of life, and progresses most rapidly after the fourth year. An example or two taken from the history of beds of known age will show how important it is to let the oysters have any time that is possible after the fourth year in which to increase, not in size, and certainly not in numbers, but in value. The successive valuations of the bed ot oysters now being fished on the Muttuvaratu Paar was as follows :—

In November,	1903,	at the average	age of	$2\frac{1}{2}$	years,	1·50	rupees per thousand.
,,	1904,	,,	,,	$3\frac{1}{2}$	,,	3·15	,, ,,
,,	1905,	,,	,,	$4\frac{1}{2}$	,,	22·69	,, ,,

Finally, these oysters have sold (March, 1906) at prices frequently exceeding 30 rupees per thousand, and on one day even exceeding 40 rupees.

A striking example of increased pearl-production, and enhanced market value, is seen in the case of the remainder of a large bed of oysters on the South-east Cheval, most of which was prematurely fished along with the South Cheval in 1905.

In November,	1904,	it was	valued at	10·76	rupees per thousand.
,,	1905,	,,	,,	52 to 58	,, ,,

In March, 1906, the oysters when fished sold, after the first week, at rates ranging from 112 to 282 rupees per thousand.

These oysters were, on the average, 3 years old in November, 1904, and were therefore fished in 1905 when under 4 years. At the present time those that remain are in their fifth year ; and if the whole of this bed, with the neighbouring South Cheval of the same age, had been held over for the present fishery (1906), there can be no doubt that, although the number of oysters might have been somewhat reduced, the increase in pearls and in value would have been great.*

VII. Dredging.

The results of our cruises in the "Lady Havelock," detailed in the "Narrative," showed clearly the advantages of dredging both as a method of exploring and surveying the banks, and also for the purpose of raising considerable quantities of oysters from the bottom in a short time. Worked from a handy, seaworthy vessel, of the type of a large tug, or a modern steam trawler, with a steam winch near the stern, the dredge becomes in practised hands an instrument of precision, and will bring up a fair sample of everything on the ground, including the bottom deposit.

* A letter just received from the pearl-fishery camp at Marichchukaddi states that "the merchants are very pleased with the oysters of the South-east Cheval." . . . . "They say there never has been anything like it as to results, and large profits have been made by several."

Moreover, the operation is a speedy one. A line of soundings and dredgings can be run over a very considerable area in one day's work, and a much larger and more continuous, and therefore more representative, sample obtained than would be possible by diving. From such a steamer, on the occasion of a fishery, six dredges at least could be worked simultaneously, and mechanical contrivances might be devised for increasing the number still further. There need be no fear that dredging operations will be destructive to any young oysters that may be mixed with the old, or will in any way damage the ground as an oyster paar. Dredging is the usual practice on oyster beds in Europe and America, and it is well known that a certain amount of dredging improves the condition of a bed.

Our results on the "Lady Havelock" showed that neither young nor old oysters brought up by the dredge are injured, and it would be a simple matter on the steamer to separate the young and return them to the water or transport them to other ground; while it would be very difficult, if not impossible, to get this done in the divers' boats under present conditions.

On several occasions, as shown in the "Narrative," we discovered, by dredging, considerable numbers of pearl oysters on spots not recognised as known "paars." I feel confident, from the nature of the ground and our knowledge of other conditions (such as depths, currents, and the free-swimming stages of the young pearl oyster), that new deposits of spat must make their appearance from time to time at new localities, and may appear any time on some grounds outside the recognised paars—and all such new beds will probably remain unknown unless discovered by dredging traverses across the whole oyster-bearing plateau of the Gulf of Manaar. At several localities we examined the ground outside the known paars down to the 100-fathom line, with the view of ascertaining whether there is any evidence in support of statements which have sometimes been made to the effect that there were probably unknown beds of pearl oysters further out and in deeper water, from which spat was produced for the supply of the in-shore paars. No such evidence was obtained. All fresh spat which has appeared in the past after grounds have been cleared by fishing must, then, have come from other beds of adult oysters upon the plateau within the 10-fathom line—beds which have remained unknown and unfished. Kutiramalai Paar, fished in 1905, is an instance of a great bed of oysters growing to maturity outside the limits of the recognised paars. At the inspection which followed the fishery in the present year, Mr. Hornell found mature oysters in quantity to the north-north-east of the Muttuvaratu on ground that is not recognised as a paar and has never been inspected.

In addition to beds of adult oysters which may in this way be found by dredging traverses, it must be remembered that newly-established deposits of young oysters upon unsuitable ground where they cannot mature will be certainly made known from time to time, and this will give the material for re-planting paars recently cleared by a fishery. Our experiments showed that young oysters are more easily

transported than older ones, and more readily re-establish themselves on new ground.

The thinning out of overcrowded beds, sometimes a very necessary operation, can be carried on concurrently with transplantation to a depleted area. For example, in November, 1905, the dredging carried on amongst the overcrowded young oysters of the Mid-east Cheval relieved pressure on that bed and at the same time provided a stock for replenishing the denuded South Cheval Paar.

As I have pointed out in a previous volume of this Report, it must be remembered that the utility of dredging is by no means confined to the finding and fishing of adult oysters, but is really manifold, and consists in the following, at least :—

(*a*) In exploring the ground ;
(*b*) In fishing oysters ;
(*c*) In cleaning the ground and removing starfishes and other enemies ;
(*d*) In thinning out overcrowded beds ;
(*e*) In oyster transplantation.

The value of dredging is not properly assessed if account be taken of only one of these, such as fishing, or even of fishing and transplanting alone. Finally, it is important to bear in mind that several of these useful operations can usually be carried on simultaneously in the same series of dredgings.

VIII.—Other Marine Economic Work.

In regard to the fish-trawling operations, I have to report that the greater part of Palk Bay presents a large open expanse with a uniform soft bottom suitable for trawling. Our hauls in both the northern and the southern parts of the area showed that there are plenty of fish, and apparently this shallow sea serves as a very valuable nursery for young sea-fish. We also found off Galle, to the east of the Gallehogalle Bank, at a depth of 25 to 30 fathoms, an area which may be regarded as a fish-nursery. Here it is evident that the young of both flat and round fish, belonging to about ten species and including such valuable forms as may be called "Soles," "Turbot," and "Plaice" (although not the same species as those in home seas), congregate in large numbers.

Fig. 17. The commercial sponge (*Euspongia officinalis*, var. *ceylonica*) from Trincomalee, as seen when alive; reduced in size.

It will naturally be part of the duty of the Marine Biologist to the Colony to make himself acquainted with the conditions of the native fisheries, and be prepared to advise as to whether facilities should be given for introducing trawling

in suitable localities, or whether any regulations are required for the protection of the fish-nurseries.

As an example of an additional investigation such as will naturally be undertaken by the Marine Biologist, I may note that during our visit in February, 1902, to Trincomalee, we found the commercial sponge living in the harbour (fig. 17). I asked Mr. HORNELL to return later in the year and look into the matter. He did so in October, and was very successful in determining the localities and mode of growth of the sponge—which is a variety of the true *Euspongia officinalis*, and is very similar to the Mediterranean form. Professor DENDY, the sponge specialist, who has examined samples for me, thinks well of the quality, and says, "the possibility of establishing a sponge-fishery is worth consideration" (see also Part III., p. 211).

Fig. 18. The edible rock oyster of Ceylon (*Ostrea cucullata*).

An edible oyster (*Ostrea cucullata*, see fig. 18) is abundant on some parts of the Coast of Ceylon. The "trepang" and other marine industries are also worthy of attention.

IX. THE MARINE BIOLOGICAL STATION.

For the proper carrying out of our work in Ceylon it was found necessary to fit up the scientific man's workshop—a small laboratory on the edge of the sea, with experimental tanks, a circulation of sea-water and facilities for microscopic and other work. For several reasons, which were given fully in the "Narrative" (Part I., p. 87), we chose Galle at the southern end of Ceylon, and we had, at first, every reason to be satisfied with the choice. With its large bay, its rich fauna and the sheltered collecting ground of the lagoon within the coral reef, it is probably one of the best possible spots for marine biological work in Eastern tropical seas. But as time went on it became clear to Mr. HORNELL that, for experimental work with the pearl oyster, such as he required to undertake in the course of his investigations, a larger area than

could be obtained in artificial tanks, and a more sheltered one than the bay at Galle during the south-west monsoon, was essential. Fortunately, some very suitable buildings, in the best possible place, then passed into the hands of the Colonial Government through the abandonment of Trincomalee as a Naval Dockyard Station; and on being consulted last year by Sir HENRY BLAKE and the Colonial Office, I was able to concur with Mr. HORNELL and recommend strongly that the Marine Biological Station be transferred from Galle, in the south of the island, to the former Naval Hospital at Trincomalee, on the north-east coast. That transference has now been effected, and the magnificent almost land-locked inner bay at Trincomalee, in which pearl oysters naturally live in shallow water, is now available for experimental scientific work at all times of the year.

It is clear to me, in concluding this Summary of Results obtained so far, (1) that there is still a great deal of biological work that must be done in connection with all the Ceylon marine fishing industries; and (2) that the Marine Laboratory now at Trincomalee, enlarged if necessary and more fully equipped, is the best place in which to carry on all such investigations, and ought in the future to play an important part in the scientific work of the colony.

B.—RECOMMENDATIONS.*

The following Recommendations are based upon the conclusions briefly given in the preceding pages and also upon the detailed evidence in the "Narrative" and other sections in the preceding volumes of this Report.

1. That dredging be employed extensively to supplement diving operations, either wholly or in part, both on the inspections and also, where possible and when desirable, at the fisheries.

* These Recommendations, sent to the Governor of Ceylon in September, 1903, as a private document accompanying an "advance" printed copy of the first volume of this Report, are subordinate to my primary proposition, which was that the Colonial Government should appoint a Marine Biologist to carry on the investigations I had started. This proposition and my further recommendation that Mr. JAMES HORNELL, F.L.S., should be appointed to the post, were adopted, and Mr. HORNELL commenced his work as Marine Biologist to the Government on January 1st, 1904. A few weeks later, on the retirement of the Master Attendant of Colombo from the office of Inspector of Pearl Banks, the duties of the latter post were, temporarily, added to those of the Marine Biologist, and since that date Mr. HORNELL has acted in the dual capacity, and has thus discharged both advisory (biological) and executive (inspectional) functions in connection with the pearl banks during the last two years. The record fisheries of 1904 and 1905 have taken place under the new auspices, and of the latter (the great fishery of 1905 which brought in over £150,000 profit to the Government) it is gratifying to find that His Excellency Sir HENRY BLAKE has placed on record in his despatch of June 14th, 1905, to the Secretary of State that "This result is due to the careful and methodical examination of the banks by Mr. HORNELL."

2. That a steamer be provided, of the type of a modern steam-trawler, from which a number of dredges could be worked simultaneously; and be fitted with tanks or "fish-wells" in which large numbers of pearl oysters could be transported.

3. That attention be paid to inspecting not merely the known paars, but also to traversing with the dredge at least once a year certain lines across the pearl bank plateau, in order to search for new deposits of oysters.

4. That whenever young oysters are found in quantity on the Periya Paar or other localities where there is very little prospect of their ever arriving at maturity, as many as possible should at once be dredged up and transplanted to more favourable grounds, to be determined by careful examination of the bottom conditions and the stock of oysters already present.

Such transplantation, in order to be successful, must be conducted on a large scale. There can be no doubt that even healthy beds of oysters on favourable ground tend to diminish as they grow older, and may sometimes from the action of their natural enemies become greatly reduced in numbers before arriving at fishable age. The bed of $1\frac{1}{2}$-year-old oysters on the Muttuvaratu Paar, which was estimated in March, 1902, as 277 millions, was found in November, 1904, to be reduced to about 20 millions. Again, the bed of 3-year-old oysters on the West Cheval Paar, estimated at 123 millions in February, 1902, was found two years later to be reduced to 35 millions. No doubt these are exceptional cases, but the conclusion to be drawn is that in transplanting young oysters it is necessary to deal with large numbers, so as to allow for the natural decrease which will inevitably take place.

5. That during an inspection, or a fishery, when large quantities of young pearl oysters are found associated with older ones, or when an immature bed is obviously overcrowded, as many as possible of the young should be removed, by dredging and sorting, and be saved by transplanting to other paars unoccupied at the time. Dredging can also be made use of to remove great numbers of sponges, crabs, star-fish, and other enemies of the pearl oyster from the productive paars.

6. That if dredging cannot be wholly substituted for diving at the fisheries, at least the dredges should be kept in readiness, so that in the event of the divers failing to obtain sufficient oysters in the limited time, or in case the fishery should be unfortunately stopped prematurely by an epidemic or other unforeseen occurrence, the remaining mature oysters on the bottom may not all be lost, but may, by means of the dredges, be brought to the surface speedily in bulk.*

7. In order to increase the area available for the attachment and growth of young pearl oysters, large areas of the sandy bottom adjoining the more important paars, especially the Cheval Paar, should undergo artificial "cultching," that is, should have broken material, such as fragments of dead coral, lumps of rock and other rubble, scattered over the bottom. Such material can be obtained in quantity close to hand

* On February 4th, 1902, on the Periya Paar, in 15 minutes, one dredge brought up 14,912 young pearl oysters,

on the shores and reefs of the Gulf of Manaar, and the transport and distribution could be effected easily by means of the steamer.

8. In order to facilitate the search for new deposits of young oysters, "drift-bottle" experiments should be made, so as to determine the prevalent currents in the Gulf of Manaar, at the breeding times of the oysters.

9. Very young "spat," such as is sometimes found in great abundance attached to floating weeds, should be saved from being carried away by the currents, and may be deposited on the bottom along with suitable cultch, to which it can adhere.

10. That, in order to determine when and how the dredges should be used; where from and where to, and in what quantities, the transplantations of young oysters should be made; which mature oysters, if any, should be retained as a breeding reserve: where and how the "cultching" should be carried out, and similar matters, a Marine Biologist should be appointed as a permanent official to take part in all inspections and fisheries, to advise as to the farming operations, and carry out the work when sanctioned, and generally to supervise the pearl-oyster banks and assist in regulating the fisheries.

11. That the Marine Biologist be charged, as his first duty, with the farming of the pearl-oyster banks in such a manner as to aim at ensuring a more constant supply of mature oysters. He should search at each inspection, and where possible during a fishery, for new spat and for fresh beds of young oysters, should locate the oysters of different ages, transplant them when necessary, thin them out when overcrowded, remove young which would necessarily be killed during the fishing of the old, or would prevent their neighbours' growth; and thus he should endeavour to have all the more reliable paars occupied by stocks, some in one and some in another stage of growth, and to bring on a succession of adults ready for fishing. He should also see to the cleaning of the banks by dredging and the removal of enemies of the pearl oyster, should improve the bottom by laying down artificial cultch, and should maintain adequate breeding reserves of adult oysters. He should advise in all cases that the order of fishing of the beds be determined by practical biological considerations, affecting not merely the interests of a particular fishery, but the future prosperity of the industry.

12. That during the time of the monsoons, when it would be impossible to work in the Gulf of Manaar, the Marine Biologist should carry on his investigations at the marine laboratory. There will be plenty to do in connection with the life and growth of the pearl oyster, and the formation and abundance of pearls, to occupy his attention even if he had no other work.

But as secondary duties, when not fully occupied with pearl-oyster questions, I would recommend that the Marine Biologist should be instructed to investigate the "window-shell" oyster fishery at Tampalakam, the pearl oyster at Trincomalee and elsewhere on the East Coast, the edible oyster at various localities, the trepang fishery, chank diving, the possibility of establishing a commercial sponge fishery at

Trincomalee, and the native fish-trawling industries. With these and other practical applications of science which he would discover and make known, the time and energies of the Marine Biologist would be more than fully occupied throughout the year in useful work for the Colony.

13. If these recommendations are adopted and a Marine Biologist is permanently charged with the work of conserving and promoting the pearl-oyster and other fisheries, he must be given the means of carrying on his work satisfactorily. For inspecting, dredging, cultching, and transplanting, a steamer is necessary. It need not be large nor swift, but it must be fit for the work and specially fitted with the tanks, winch, dredges, &c., which will be necessary. He will also require laboratory equipment on shore, and the usual mechanical and clerical assistance; but it is not obvious that any useful purpose can be served, under the circumstances, by establishing a small laboratory at Aripu or elsewhere in the Gulf of Manaar (as had been suggested). It must be clear to any scientific man who knows the locality that any biological work on the pearl banks must be done at sea, from a ship, during the inspections and fisheries, and cannot be done at all during the monsoons because of the heavy sea and useless exposed shore. At these latter times the necessary laboratory work, supplementing the previous observations at sea, could be done much better at Colombo, at Galle, or at Trincomalee, than at Aripu or Manaar.

14. Consequently I recommend that the Marine Biological Laboratory, now at Trincomalee, be regarded as the headquarters of the Government Marine Biologist's work; and that, in the interests both of the various fishing industries and also of scientific investigation in general, the institution be established at once on a permanent basis, with suitable assistance and equipment. The building ought, moreover, to be of sufficient size to accommodate two or three additional zoologists, such as members of the Staff of the Museum and of the Medical College at Colombo, or scientific visitors from Europe. The work of such men would help in the investigation of the marine fauna and in the elucidation of practical problems, and the laboratory would soon become a credit and an attraction to the Colony. Such an institution would be known throughout the scientific world, and would be visited by students of science from other countries, and it might reasonably be hoped that in time it would perform for the marine biology and the fishing industries of Ceylon very much the same important practical functions as those fulfilled by the celebrated Gardens and Laboratory at Peradeniya for the botany and associated economic problems of the land.

W. A. Herdman.

EXPLANATION OF PLATE.

Figs. 1 and 2. Living eggs of *Margaritifera vulgaris*, immediately after emission.

,, 3 and 4. Preserved ovarian eggs, as seen in sections of the mature gonad. × 900.

Fig. 5. The spermatozoon, highly magnified.

Figs. 6, 7, and 8. Segmentation stages.

[The exact magnification of these figures, drawn in Ceylon, is not known.]

Fig. 9. Segmentation nearly completed, embolic gastrula. Fig. 10. Optical section of the same stage.

,, 11. Embryo showing first appearance of the zonal band of cilia, and differentiation of posterior end.

,, 12. Optical section of the same stage.

,, 13. Early trochophore stage, 22 hours after fertilisation.

,, 14. Trochophore four hours later.

,, 15. Optical section of the same stage. *a*, prostomium; *b*, apical tuft of cilia; *c*, præ-oral circlet of cilia; *d*, blastopore; *e*, enteron; *f*, posterior ciliated patch.

,, 16. Trochophore four hours later—30 hours after fertilisation.

,, 17. Two unfertilised ova, three days after extrusion.

,, 18. Free-swimming larva, three days after fertilisation, showing the first appearance of the shell.

,, 19. Free-swimming larva caught along with surface plankton in the tow-net.

,, 20. An older form when ready to settle down as the young fixed pearl oyster.

,, 21. Another larva of about the same age, showing especially the otocyst (enlarged at 21*a*), and the long mobile foot *f*, which can be extended far beyond the shell.

Figs. 22 to 27. Stages of growth in the shell of the fixed spat, from 0·4 millim. to 1·5 millims. across. Fig. 22 shows practically the same stage as fig. 19, although the latter was free and the former fixed. In fig. 27, *p*. indicates the prodissoconch, *s*. the prismatic shell, and *n*. the portion lined by nacre.

,, 28 and 29. Two views of the hinge, showing the simple, regular, interlocking teeth.

Fig. 30. Part of the shell in the 0·6-millim. stage (fig. 23), showing the characters of the prodissoconch (*p*.), of the prismatic shell (*s*.), and of the cuticular margin (*m*.). × 900.

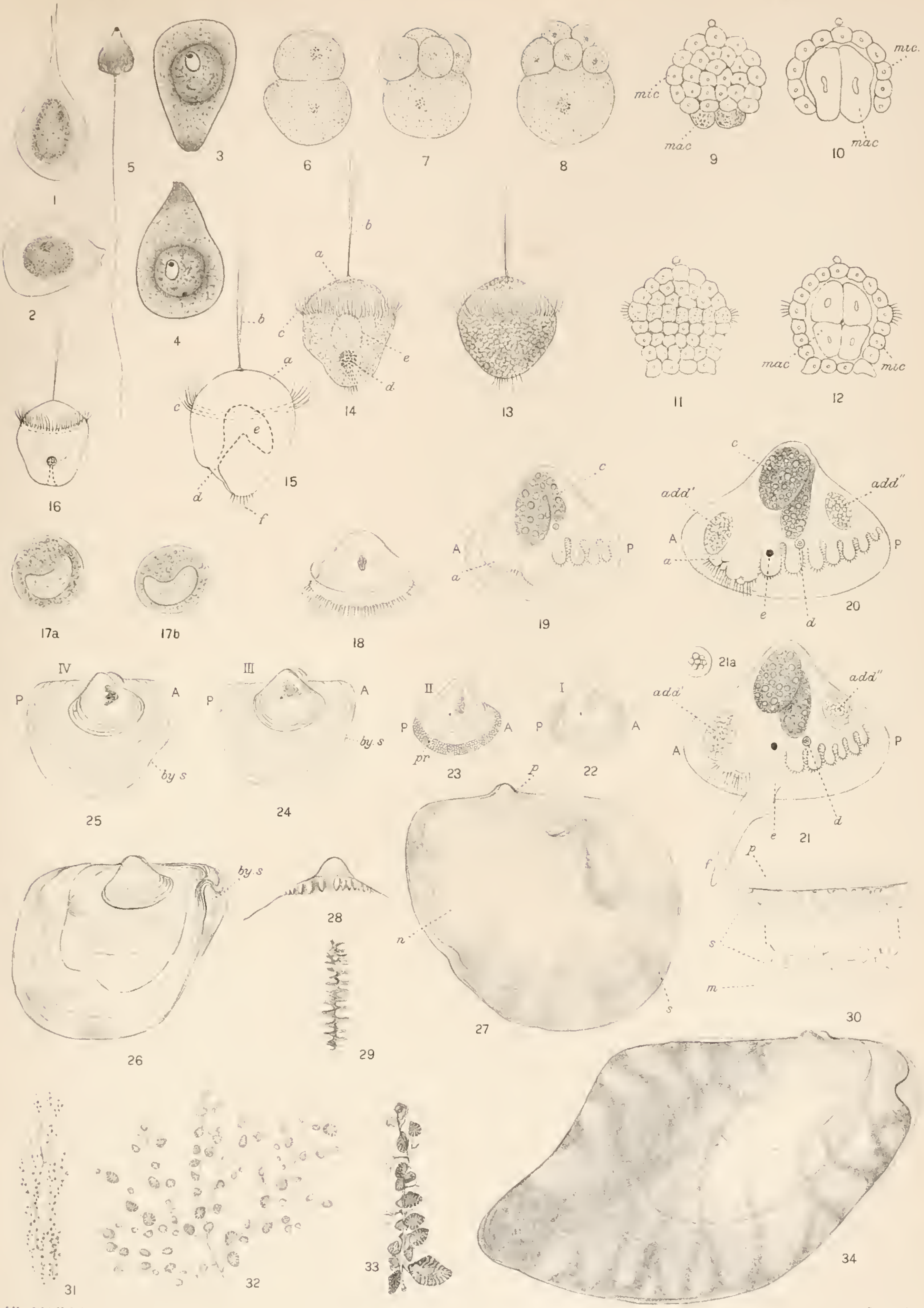
,, 31. Very young spat (0·4-millim. stage) on filamentous Algæ. Natural size.

,, 32. Older spat of various sizes on Algæ. Natural size.

,, 33. "False spat" (*Avicula vexillum*) on Algæ. Natural size.

,, 34. Young *Avicula vexillum* ("false spat"). × 40.

Fig. 19. Bank of "window-shell" oysters (*Placuna placenta*), remaining from the last fishery in Lake Tampalakam, at Trincomalee.



I H & W A H, del E Wilson, Cambridge

LIFE-HISTORY OF PEARL OYSTER.

REPORT

ON THE

CIRRIPEDIA

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

N. ANNANDALE, D.Sc., C.M.Z.S.,
DEPUTY SUPERINTENDENT OF THE INDIAN MUSEUM, CALCUTTA.

[WITH NINE TEXT ILLUSTRATIONS.]

INTRODUCTORY.

I HAVE to thank Professor HERDMAN for sending his Ceylonese Barnacles to me for description. The collection is small, including examples of only eleven species; but some of these species are of considerable interest. Indeed, so little is known of the Indian Cirripedes that any specimens with accurate localities are of value. Professor HERDMAN has asked me to add to my report a list of the species known from Ceylon and the Gulf of Manaar. I have interpreted the request freely, adding notes as well as names in the case of forms of which I have examined specimens, even if they are not represented in the collection under review.

Every addition to our knowledge of the Barnacles tends to prove the wide distribution, not only of genera, but even of species and varieties. It is, therefore, impossible to draw precise geographical conclusions from the presence of any form in a local fauna, while its absence often means no more than that it has not been observed. The following list, in which the species obtained by Professor HERDMAN are indicated by a star, gives the names and known distribution of those recorded hitherto or for the first time in the present Report. There can be no doubt that further research will greatly increase the number found both in the Gulf of Manaar and in the Bay of Bengal.

Professor HERDMAN informs me that some species of *Balanus* are of real economic importance in competing for food with the pearl oyster in the Gulf of Manaar.

BARNACLES KNOWN FROM CEYLON.

LEPADIDÆ.	DISTRIBUTION.
1. *Lepas anserifera*, L.	Cosmopolitan.
*2. ,, *anatifera*, L.	,,
3. ,, *tenuivalvata* (ANNAND.)	Ceylon.
4. *Dichelaspis equina*, LANCH.	East coast of India, Maldives, Ceylon, Burma, Malaya.
5. ,, *pellucida*, DARW.	East coast of India, Ceylon, Burma.
6. *Pœcilasma kæmpferi*, DARW.	Gulf of Manaar, Malaysia, Japan, Madeira.
7. *Scalpellum gruvelii*, ANNAND.	Gulf of Manaar, Laccadives, Andaman Sea (859 to 1022 fathoms.)
8. ,, *alcockianum*, ANNAND.	Gulf of Manaar, Andaman Sea (859 to 960 fathoms).
9. ,, *japonicum*, HOEK	Gulf of Manaar (595 to 556 fathoms); Japan (565 fathoms).
10. ,, *squamuliferum*, WELT.	Deeper Indian seas (112 to 1840 fathoms); Japan.
? ,, *truncatum*, HOEK	Between New Guinea and Australia (1400 fathoms); (?) Gulf of Manaar (590 fathoms).
11. ,, *tenue*, HOEK	South of Indian Ocean (1375 fathoms); Gulf of Manaar (595 to 556 fathoms); Bay of Bengal (199 fathoms).
12. ,, *subflavum*, ANNAND.	Gulf of Manaar, Gulf of Oman, Andaman Sea, west coast of India (130 to 700 fathoms).
BALANIDÆ.	
13. *Chelonobia testudinaria* (L.)	Gulf of Manaar, warm and temperate seas.
14. *Creusia spinulosa*, LEACH	Ceylon, Indian Ocean and Central Pacific, West Indies
*15. *Pyrgoma conjugatum*, DARW.	Red Sea, Ceylon, Mergui.
*16. *Tetraclita serrata*, DARW.	South Africa, Ceylon.
*17. *Acasta cyathus*, DARW.	Ceylon, South America, Australia, Madeira.
*18. ,, *funiculorum*, n. sp.	Ceylon.
*19. *Balanus tintinnabulum* (L.).	Cosmopolitan.
*20. ,, *amphitrite*, DARW.	Warm and temperate seas.
*21. ,, *amaryllis*, DARW.	Indian Ocean and Central Pacific.
*22. ,, *allium*, DARW.	Red Sea, Ceylon, Western Australia.
*23. ,, *terebratus*, DARW.	Maldives, Ceylon.
*24. ,, *æneas*, LANCH.	Malaya,† Ceylon.
*25. ,, *maldivensis*, BORR.	Maldives, Ceylon.
‡26. *Chthamalus stellatus* (POLI)	Warm and temperate seas.

† It is convenient to confine the term "Malaya" to the Malay Peninsula, south of the Isthmus of Kra, and the small adjacent islands, such as Singapore and Penang, giving "Malaysia" a wider significance, to include the great archipelago.

‡ In addition to the above-mentioned species, I have lately examined specimens of a variety of *Conchoderma hunteri*, OWEN, taken by Mr. E. E. GREEN on a sea-snake (*Hydrus platurus*) from Ceylonese waters. Their valves are of typical form, but very small and feebly calcified. The relative length of the peduncle varies considerably. The integument is transparent and almost colourless; but faint vertical bars can be detected on it in certain lights.—*April* 30, 1906.

DESCRIPTION OF THE SPECIES.

LEPADIDÆ.

*Lepas anatifera, L.

Localities:—Galle (on a buoy rope) and Cheval Paar, Gulf of Manaar.

Several of the specimens from the Cheval Paar belong to DARWIN'S var. A.

It is often almost impossible to distinguish tropical examples of this species from *L. anserifera* by mere examination of the shell. The pale colour of the upper part of the peduncle is a good diagnostic character of the latter, but one which cannot always be detected in faded or shrunken specimens. The only safe method of distinguishing the two species is to examine the filamentous appendages.

L. anserifera appears to be more abundant in the Bay of Bengal than *L. anatifera.* So far as my experience goes, examples of both species from the Indian region are generally small; indeed, it seems probable that they do not reach the same dimensions, except very occasionally, as those attained by individuals reared in higher latitudes. Their stalk, especially, is frequently stunted.

Lepas tenuivalvata (ANNANDALE) (14).

In my account of this species (as *Dichelaspis tenuivalvata*) I did not describe the penis or the anal appendages. Having now been able to dissect a specimen in detail, I am in a position to give an account of these organs. The penis is long, slender, tapering, with a few scattered hairs on its surface. The anal appendages are uniarticulate, claw-shaped, and naked. Taking these characters into account, the species should probably be placed in the genus *Lepas.* In placing it in *Dichelaspis,* I relied chiefly on the shape of the carina. The specimens are probably immature, but the shape of this valve distinguishes it from any other representative of the former genus.

Dichelaspis equina, LANCHESTER (8).

Some doubt as to the difference between this species and GRAY'S *Octolasmis warwickii* is hinted at by GRUVEL (10). The most constant external character of the former is the division of the carina into two parts by a horizontal cleft near the base of the capitulum. I have now examined a large number of specimens, which vary greatly as regards the shape of the terga and the transparency of the membrane, and all agree in this respect. It seems to be a good specific character; but two distinct forms have probably been confused, if DARWIN'S figure (1) is correct, under the name *D. warwickii* (see figs. 2 and 3).

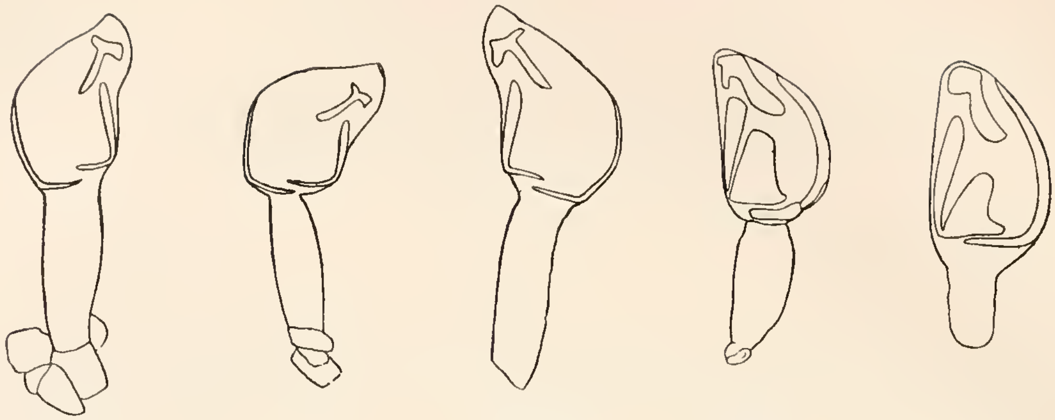


Fig. 1A. Fig. 1. Fig. 1B. Fig. 2. Fig. 3.

Figs. 1, 1A, 1B. *Dichelaspis pellucida*, Darwin. Fig. 2. *Dichelaspis equina*, Lanchester.
Fig. 3. *Dichelaspis warwickii* (Gray)—After Darwin.

D. equina is the commonest member of its family found attached to crabs from shallow water off Ceylon and the east coast of India.* It occurs both on species which swim near the surface and on those which crawl on the bottom, and is occasionally taken on sea-snakes, though less frequently than *D. pellucida*. On the crabs it does not confine itself to any particular part of the body. The following is a list of the Crustaceans on which I have found it :—*Neptunus gladiator*, *N. pelagicus*, *Scylla serrata*, *Doclea ovis*, *Egeria sp.*, *Areania septemspinosa*, and *Dorippe dorsipes*.

Dichelaspis pellucida, Darwin (1).

I have recently examined a considerable number of specimens of this species from the coasts of Burma and Ceylon. They vary considerably not only in size and in the shape of the valves, but also as regards the degree of calcification of these structures and of transparency of the membrane, as well as the form and the relative proportions of the peduncle and capitulum. Figs. 1, 1A, and 1B show the outline of some specimens in the Indian Museum. Transparency, outline and proportions probably alter considerably if specimens are not carefully preserved. It seems not improbable that Darwin's *D. grayii* and *D. pellucida* are identical, in which case the former name would have precedence, as the description is printed before that of *D. pellucida*. I have no doubt that Gruvel's *D. lepadiformis* also belongs to the same species, although I separated it in my recent list of the Indian Lepadidæ (13). His account of the penis (12), which is the most striking feature of the form, does not differ very materially from Hoek's description of that of *D. pellucida* (4), to which description no reference is given in Gruvel's monograph. Judging from specimens I have examined, the exact outline of the penis in the more

* Since this was written specimens have been received at the Indian Museum from the Persian Gulf.—*April* 30, 1906.

delicate species—and *D. pellucida* is one of the most delicate—depends to some extent on the state of preservation of the specimen examined.

D. pellucida has only been found on sea-snakes. It occurs most commonly, in Indian seas, on *Hydrus platurus;* but I have seen it on more than one species of *Distira*.

Pœcilasma kæmpferi, Darwin **(1).**

The Ceylonese specimens (from 430 fathoms in the Gulf of Manaar) I have examined belong to the typical form of the species, which is probably circumtropical. It is found attached to various prawns.

Scalpellum gruvelii, Annandale **(15).**

I give an outline of the valves of this species (fig. 4). It is one of the larger members of the section of its genus with imperfectly calcified valves, the figure being twice natural size. In the variety *quadratum*, also from the Gulf of Manaar, the carina is much more strongly bowed, and in the typical form the preumbinal portion of the carina is often relatively more extensive. The section to which this species belongs merges gradually into that with fully calcified valves, but the division is convenient for the sake of reference. In *S. gruvelii*, as in *S. alcockianum*, *S. laccadivicum*, and *S. japonicum*, the plates are actually imbedded in membrane, and traces of the imperfectly calcified parts which are not fully formed can be detected. In *S. inerme** from near Java, on the other hand, not only are the valves very much stouter, despite the shape of the tergum, but they are lightly attached to the inner surface of the membrane and their outlines are quite sharp.

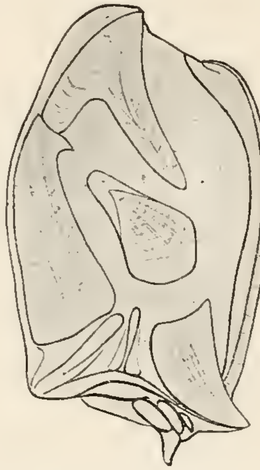


Fig. 4. *Scalpellum gruvelii*, Annandale. ×2.

S. gruvelii is only found at great depths, at which it is not uncommon in the Indian seas.

Scalpellum japonicum, Hoek **(3).**

Locality :—Gulf of Manaar, 595 to 556 fathoms (R.I.M.S. Ship "Investigator").

Col. Alcock has recently called my attention to certain Barnacles attached to living shells of *Turbo indicus* from the above locality. Two of them agree with Hoek's description and figures of *S. japonicum* from Japanese seas. *S. laccadivicum*, which will also be found (in all probability) in the Gulf of Manaar, is related to this form, but has the valves less imperfectly calcified, especially in the variety *investigatoris*.

* I understand that Hoek regards this form as a variety of *S. stearnsii*, Pilsbury ; but his paper, read before the Royal Academy of Sciences of Amsterdam in January, has not yet reached Calcutta.—*April* 30, 1906.

Scalpellum squamuliferum, WELTNER (6).

The adult of this Barnacle is characterised by the possession of two well developed ovigerous lamellæ, which are absent from young specimens. They take the form of stout filamentous outgrowths of the integument of the body wall, rounded posteriorly and grooved on their anterior surface. The tip is generally pointed, but may be bifid, and the lamella is often more or less distinctly jointed. The lamellæ may be compared as regards relative position and extent with those of *Cryptophialus*, being situated, one behind the other, on the dorsal aspect of the thorax; the eggs form a two-layered, coherent mass surrounding the back and sides of the body, and the lamellæ are imbedded in them. These structures will be figured in the next number of the "Illustrations of the Natural History of the R.I.M.S. Ship 'Investigator,'" 1906.

I include this species among the forms recorded from the Gulf of Manaar because it is the most abundant deep-sea Lepadid in the Bay of Bengal, and has been taken just outside the Gulf to the north-west.

? Scalpellum truncatum, HOEK.

Locality:—Gulf of Manaar, 590 fathoms (R.I.M.S. Ship "Investigator").

There is a specimen in the "Investigator" collection from the Gulf of Manaar which probably belongs to this species. It differs from HOEK's figure, however, in the following particulars:—(1) The carina is relatively longer, and (2) the valves are not so closely knit together. As I have only examined one specimen, and as HOEK has only described the external characters of his single example, I do not feel quite certain of my identification; but several deep-sea species vary as regards the characters indicated.

S. truncatum was described from a depth of 1400 fathoms; but several of the Indian members of the genus have a greater range in depth than the identification of the "Investigator" specimen with HOEK's species would imply. It is noteworthy that in the Indian seas the genus is only found at a considerable depth, probably always below 100 fathoms, although in more temperate latitudes it occurs in 15 fathoms and downwards. It is probably unable to endure warm water, although it is found in every sea.

Scalpellum tenue, HOEK.

Locality:—Gulf of Manaar, 595 to 556 fathoms (R.I.M.S. Ship "Investigator").

Four specimens, together with those of *S. japonicum* recorded above, from the shell of *Turbo indicus*. My *S. subflavum* is very near this species, from which it is most readily distinguished by its smoother shell.

S. tenue was described from the south of the Indian Ocean. The only other specimen in the Indian Museum is from a depth of 1997 fathoms, in the Bay of Bengal.

Scalpellum subflavum, ANNANDALE (15).

This species belongs to the section of its genus with perfectly calcified valves and a simply bowed carina, as do all the species which have the first of these characters that have been recorded from the immediate neighbourhood of India.

It is almost as commonly found in the deeper parts of the Bay of Bengal (especially in the Andaman Sea) as is *S. squamuliferum*, but is rarer because less gregarious. More than two individuals are seldom found together. I have examined several specimens from the Gulf of Manaar.

BALANIDÆ.

Chelonobia testudinaria (L.).

THURSTON (7) records this species from Ráméswaram Island, and there are specimens (on the carapace of *Chelone imbricata*), which are probably from the Gulf of Manaar, in the Indian Museum.

Ch. testudinaria appears to be found most frequently on turtles, in all warm and temperate seas, but not to be confined to any one species; indeed, it has been observed on the shells of molluscs. GRUVEL (11) has recently described a species of the same genus from the skin of *Manatus senegalensis* under the name *Ch. manati*. I could obtain no evidence during a recent visit to the Gulf of Manaar that Barnacles are ever found on *Halicore* there.*

Creusia spinulosa, LEACH.

This species is recorded from Ceylon by WELTNER (5). I have examined specimens from Mergui on the lower surface of *Turbinaria crater*. They are of considerable size and have their shell covered by a thin layer of coral. In some specimens not only does the opening remain patent, but the junction between the basis and the shell, and even the divisions between the compartments, are visible on the surface, the former as a clear-cut line, not merely as a rounded furrow. The coral appears to have grown over the base and then to have commenced to climb the shell at one point, as much as possible avoiding narrowly all the depressions upon it, thus protecting the Barnacle without injuring it. Nevertheless, some examples of the Barnacle have been completely engulfed by the coral and so have perished, or else, having perished, have been engulfed.

***Pyrgoma conjugatum**, DARWIN.

Localities:—Coral reefs off Ceylon.

There are numerous specimens on fragments of *Turbinaria* evidently collected in a living state. Even when completely imbedded they can be recognised by the form

* They occur, however, on the Dugong in Australian waters (see DEXLER and FREUNDE, 'Amer. Nat.,' xl., 469, p. 69, 1906).

of the opening, which is a regular oval, while that of BORRADAILE'S (9) *P. madreporæ* from the Maldives, the shell of which is very similar, is rhomboidal.

WELTNER (5) has already recorded this species from Ceylon (on *Prionastræa acuticollis*). It was originally described from the Red Sea, and is abundant on specimens of *Turbinaria* and *Porites* collected by the late Dr. J. ANDERSON in Mergui.

Professor HERDMAN'S specimens occur on both the upper and the lower surface of the *Turbinaria*, but chiefly on the latter. In either case they have been covered by the living tissues of the organism while still small. In younger individuals the basis is almost flat as a whole, but deeply sulcated and with an oval depression, corresponding to the opening of the shell above, in the centre. The shell is conical. As the calcareous substance of the coral is deposited round them, the shell becomes relatively flatter and the base deeply concave from within. The whole animal is finally buried. An opening is retained for a time by the action of the cirri and possibly of the opercular plates; but in some examples examined even this has been closed over and the Barnacle has perished, its presence being indicated by a smooth, rounded mound on the surface of the coral. The division between shell and basis can usually be detected, however, on the surface of the coral. A cyst in which the opening still remains open measures 9 millims. in depth, 14 millims. in length, and 10 millims. in breadth, all the measurements being taken externally. The shell is about 1 millim. thick above, but slightly thicker at the point where the valves meet the basis. The internal depth is a little over 8 millims., of which the basal portion occupies 5 millims. The basis is barely distinguishable from the substance of the coral. In some Mergui specimens the cyst is twice as deep and far more protuberant on the surface of the coral, but the opening of the shell is still patent.

*Tetraclita serrata, DARWIN.

Locality :—On a dead *Heteropsammia* off Ceylon.

The presence of the operculum enables me to identify the single specimen obtained by Professor HERDMAN, which is small (antero-posterior diameter of base = 5 millims.). The species does not appear to have been recorded hitherto from the eastern part of the Indian Ocean.

*Acasta cyathus, DARWIN (2).

Locality :—South end of Cheval Paar, Gulf of Manaar.

The specimen is longer and less spheroidal than the one figured by DARWIN, but otherwise agrees closely with his figure. The shell is white instead of pink; but this may be due to the action of spirit. The basis, while nearly flat as a whole, bears a circular depression in its centre, if the shell be viewed from below. This is probably due to the presence of a minute Polychæte, which is coiled up, inside a transparent tube, within the depression.

The penis is extremely long and fine and bears a few scattered hairs. Although the remainder of the body is almost colourless, this organ is of a deep horn-colour, minutely ringed with purplish brown. The latter tint evidently represents a pigment common in Barnacles, but more usually associated with the mouth parts. In *Scalpellum alcockianum* it colours the limbs almost black, while in *Balanus æneas* it tinges the softer structures connected with the mouth. Many other examples of its occurrence might also be noted in both sections of the non-parasitic Cirripedes, both in shallow and in deep water.

A. cyathus has not previously been recorded from the Indian region, and is probably a scarce form where it occurs; but its distribution is evidently circum-tropical.

*__Acasta funiculorum,__ n. sp.—Figs. 5–9.

Locality :—Gulf of Manaar.

Diagnosis.—Rostrum and laterals greatly enlarged ; carino-laterals much reduced, generally shorter than the rostrum by about two-thirds. Radii of rostrum very

Fig. 5.

Fig. 6.

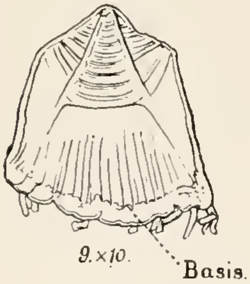


Fig. 9.

Fig. 8.

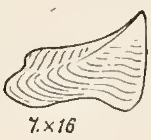


Fig. 7.

Fig. 5. *Acasta funiculorum*, n. sp., lateral view. × 10.
" 6. " " view from above. × 10.
" 7. " " tergum, external view. × 16.
" 8. " " scutum, " " × 16.
" 9. " " rostrum, internal view. × 10 (smaller specimen).

broad, longitudinally ridged, oblique. External surface of parietes and radii rough and irregularly spiny, with spiny, cylindrical processes connecting the basal part of the rostrum and the laterals with the coral to which the Barnacle is attached. Internal surface of parietes strongly sulcated longitudinally above and vertically below. Shell fragile, mound-shaped, generally narrower in front than behind, basis flat. Opening more or less vertical, irregularly oval, strongly denticulate. Colour, dirty white; where covered with epidermis, yellowish; tinged, more or less deeply, with steel-blue above. Scutum triangular, with muscular depressions feebly developed; tergum pointed above, much wider than high, with a broad, bluntly rounded spur.

Several dried specimens on the lower surface of *Turbinaria*.

I have been in much doubt as to the proper generic position of this form. As the basis is absolutely flat it can hardly be put in DARWIN'S Section B of *Balanus*, with which its true affinities may lie. On the other hand, its more or less globular outline, its fragile shell, and the shape of its compartments certainly ally it to *Acasta*, if this group can be given generic rank. The periphery of the basis is pierced by small irregular holes as in some species of *Acasta*. It is almost impossible to lay down an exact line between *Acasta* and Section B of *Balanus*; but in most cases there is no difficulty in seeing a difference as regards species.

No species of *Acasta* has hitherto been recorded from a Madreporarian coral. The present form occurs with *Balanus allium*, *B. terebratus*, and *Pyrgoma conjugatum*, and it is interesting to note the different ways in which the four species have been adapted for the same mode of life. With *P. conjugatum* I have already dealt. *B. terebratus* anchors itself among the living tissues of the coral by means of prolongations of the outstanding vertical ridges on its shell. These tissues do not grow over it as they do over the *Pyrgoma*, at least, in the specimens examined. By deepening its base, it can compensate to some extent for the growth of the calcareous part of the coral; but it appears to be continually thrust outwards on to the surface, and none of the specimens show any signs of being engulfed. *B. allium*, as far as one can see, is more frequently destroyed, several specimens having been completely buried. Possibly the peculiar smooth, glistening surface of their shell may be, however, in some way a protection to them, although the smoothness is of texture rather than actual surface. *A. funiculorum* is a more highly specialized form than either of the preceding two. Its cables, so to speak, are not prolongations of such ridges as occur on other species, but seem to be special structures, allied to the spines which occur on the shell of *A. cyathus*, but very much more highly developed; their closest homologues being the processes on the shell of *Balanus tintinnabulum*, var. *spinosus*. By means of them the Barnacle anchors itself to the slippery surface of the coral. If the coral commences to grow round it, it can save itself for a period by elongating the posterior part of its shell, so that the opening may approach the horizontal more closely than it usually does; but individuals are frequently buried and perish. It may be noted that while the *Pyrgoma*, which can be surrounded by

calcareous substance without immediate danger to itself, is scattered all over the pieces of *Turbinaria* examined, the other forms occurring with it are almost entirely confined to the inner parts of the colony (where growth is less vigorous, the maximum thickness having been almost reached), or to parts where the living tissues have been killed or weakened by boring organisms.

***Balanus tintinnabulum** (L.).

Locality:—Cheval Paar, Gulf of Manaar.

The only specimen which I can refer with certainty to this extremely variable species belongs to the variety *communis*, which I have taken also on the Pamban Channel, between the Gulf of Manaar and Palk Bay. The shell of Professor Herdman's specimen is partly covered by an incrusting Alcyonarian.

***Balanus amphitrite**, Darwin.

Localities:—Galle; Gulf of Manaar.

Numerous specimens on shells, ropes, and submerged baskets. All but one belong to the variety *venustus*, which I have taken on an *Avicula* attached to a Gorgoniid at Kílakarai, on the Indian shore of the Gulf of Manaar. The one exception represents the variety *communis*. Both these varieties have an extremely wide distribution, and Professor Herdman's specimens are quite typical.

The most interesting are those on the submerged baskets, as their approximate age is known. The baskets were put into the sea on April 17 and were drawn out on May 9. The Barnacles which had formed on them during this period measure from 3 millims. to 8 millims. in their antero-posterior diameter, while the largest individuals obtained from the same seas measure about 14 millims. It is clear, therefore, that individuals of this species take, at this season, not more than three weeks to attain more than half their adult size. I have recently recorded a case in which a specimen of *B. tintinnabulum* (12) was known to have reached a great size (diameter of base, which was approximately circular, 60 millims; height of shell, 65 millims.) in about a year at Pamban, on Rámēswaram Island.

Professor Herdman tells me that *B. amphitrite* and possibly other species grow on the shells of living pearl oysters in the Gulf of Manaar. They appear in April or May, and spread with great rapidity. Such forms may be classed as enemies of the pearl oyster.

***Balanus amaryllis**, Darwin.

Localities:—Palk Bay and Gulf of Manaar.

The majority of these specimens belong to Darwin's variety B, but a few are obscurely striped with dull pink. The opercular plates resemble those of the typical form, rather than of that noted by Weltner (5), and later described by Lanchester (8) as sub-species *dissimilis*. The specimens are all small.

***Balanus allium, Darwin.**

Locality :—Coral reefs off Ceylon.

Several small specimens on *Turbinaria*, together with *B. terebratus*, *Acasta funiculorum* and *Pyrgoma conjugatum*. Probably they are immature, as the base is nearly flat, although the shell and operculum agree with Darwin's description and figures.

This Barnacle has been recorded from the Red Sea and from Australia as well as from Ceylon. It is probably another circumtropical species, its small size and inconspicuous appearance having caused it to be neglected by collectors.

***Balanus terebratus, Darwin.**

Locality :—Coral reefs off Ceylon.

Several specimens, with those of the preceding species. They agree closely with Borradaile's description (9) as regards the structure of the operculum. Darwin (2), who had examined a single specimen, said regarding it, "the interspaces between the ridges (on the basis) are penetrated by small rounded apertures, of irregular shape and unequal sizes." Borradaile was unable to see these apertures, and they are absent in some examples I have examined. In one individual, however, there appear to be indications that they have been present, but have been almost obliterated during growth. The specimens are small, the antero-posterior diameter of the largest being 7 millims., and are apparently more steeply conical than the type.

***Balanus æneas, Lanchester (8).**

Locality :—Pearl Banks, Gulf of Manaar.

Numerous small individuals, measuring about 3 millims. in antero-posterior diameter, on a piece of sodden palm fibre, on a shell, and on dead *Heteropsammia*.

In spite of their small size these individuals contain eggs inside the shell. The eggs are of a broad ovoid outline, measure 0·333 millim. in length and 0·2 millim. in maximum breadth, and are comparatively few in number. The maxillæ have in one specimen only six teeth, the third being represented merely by a short bristle; while in the other individuals there are seven.

Loose in the shell of one specimen I found a peculiar little Nematode, the affinities of which I do not venture to decide.

***Balanus maldivensis, Borradaile (9).**

Locality :—Gulf of Manaar.

Five specimens on a piece of dead coral. Possibly some other very much worn examples, fixed to a dead *Heteropsammia*, may also belong to this species. The shells are white with vertical stripes of rose-pink. Their coloration gives them a general resemblance to some specimens of *B. amphitrite*, var. *venustus*.

Borradaile's section H of the genus *Balanus*, created for this form in 1903, is not the same as Gruvel's section H, which was published for *B. dybowskii* in the same

year. The definition of the former is "All parts of shell present, heavy, and without pores"; of the latter, "Basis calcareous; no radii; basis and parietes porous."

BORRADAILE's section approaches *Acasta* technically, although the form and character of the shell are different. It is convenient, therefore, to call it section I, retaining GRUVEL's designation for *his* section H.

Chthamalus stellatus (POLI).

A common Indian species with a wide distribution. I have lately taken specimens in the estuary of the Matla River, Lower Bengal, at a place where the water was decidedly brackish. They were attached to the trunks of mangrove trees, and could only have been covered by the tide during a very small part of each day.

On the whole, the Barnacles of Ceylon, in so far as they are known, bear out the remark made in the Introductory note to this paper, that every addition to our knowledge of the distribution of the group tends to prove the wide dispersal of the species and varieties. Of the 26 species recorded above, 3 occur in all seas, their migrations being assisted by human agency; at least 6 will probably be found in every sea which is not too cold; 4 are widely spread in the Indian Ocean and the warmer parts of the Pacific, while 12 are only known from the Indian Ocean. Of the last, however, 4 come from great depths, which have been little explored, while the remaining 8 are small, inconspicuous forms. Except *Tetraclita serrata*, which is probably found at the extreme south of the West African coast, none of the 26 species are known only from the Atlantic and Pacific Oceans. It seems possible that the continent of Africa has proved a barrier in some cases as regards the migration westwards of Oriental species.

LIST OF REFERENCES TO LITERATURE.

(1.) Darwin, C.—'A Monograph of the Cirripedia—Lepadidæ.' London, 1851 (Ray Society).

(2.) Darwin, C.—'A Monograph of the Cirripedia—Balanidæ.' London, 1853 (Ray Society).

(3.) Hoek, P. P. C.—"Report on the Cirripedia collected by H.M.S. 'Challenger.'" 'Rep. Zool.,' vol. viii., 1883.

(4.) Hoek, P. P. C.—"*Dichelaspis pellucida*, Darwin." 'Ann. Mag. Nat. Hist.,' (5) xxi., 1887; and "Fauna of Mergui," 'Journ. Linn. Soc. Zool.,' vol. xxi., 1889.

(5.) Weltner, W.—"Verzeichnis der bisher beschriebenen recenten Cirripedienarten." 'Arch. f. Naturg.,' lxiii., 1897.

(6.) Weltner, W.—"Zwei neue Cirripedien aus dem indischen Ocean." 'Sitz.-Ber. Ges. naturf. Freunde,' 1894.

(7.) Thurston, E.—"Rámésvaram Island and Fauna of the Gulf of Manaar." 'Madras Mus. Bull.,' iii., 1895.

(8.) Lanchester, W. F.—"On the Crustacea collected during the 'Skeat Expedition' to the Malay Peninsula." 'P. Z. S.,' 1902 (ii.).

(9.) Borradaile, L. A.—"Marine Crustaceans," VII. Gardiner's 'Fauna and Geography of the Maldive and Laccadive Archipelagoes,' vol. i., 1903.

(10.) Gruvel, A.—'Monographie des Cirrhipèdes.' Paris, 1905.

(11.) Gruvel, A.—"Révision des Cirrhipèdes appartenant à la collection du Muséum (Operculés)." 'Nouv. Arch. Mus.,' Paris (iv.), vol. v., 1903.

(12.) Gruvel, A.—"Révision des Cirrhipèdes, &c." ("Pédonculés"). *Ibid.*, vol. iv., 1902.

(13.) Annandale, N.—"Malaysian Barnacles in the Indian Museum, with a List of the Indian Pedunculata." 'Mem. As. Soc. Bengal,' i., 1905.

(14.) Annandale, N.—"Stalked Barnacles (Cirripedia Pedunculata) in the Colombo Museum." 'Spolia Zeylanica,' iii., 1906.

(15.) Annandale, N.—"Natural History Notes from the R.I.M.S. Ship 'Investigator' (iii.), No. 12, Prel. Rep. on the Indian Stalked Barnacles." 'Ann. Mag. Nat. Hist.,' (7) xvii., 1906.

REPORT

ON THE

MARINE HEMIPTERA (HALOBATES)

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

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[WITH ONE PLATE.]

DURING his researches in the Gulf of Manaar, Professor HERDMAN collected many specimens of *Halobates*, that interesting pelagic genus of bugs, familiar to all students of insects since the publication of BUCHANAN WHITE'S classical memoir in the 'Challenger Reports.'* These insects are allied to our common "pond-skaters," and skim over the surface of the ocean in warm latitudes, as those do over the water of ponds and streams. WALKER, who has given much attention to the habits of *Halobates* in recent voyages, states† that they dive below whenever the surface is ruffled by a breeze.

All the specimens in the present collection are referable to a new species, and as the material is abundant, the opportunity has been taken to investigate some details of the external anatomy, and in particular the structure of the ovipositor.

FAMILY: HYDROMETRIDÆ.

GENUS: **Halobates**, ESCHSCHOLTZ.

Halobates herdmani, n. sp.—Plate, figs. 1 to 19.

Length of male 5·2 millims., of female 5·7 millims. Feeler with 4th segment half as long again as 3rd, slightly shorter than 2nd (figs. 3, 4). Fore foot with the two tarsal segments sub-equal (figs. 5, 6, 9). Intermediate foot with the proximal tarsal

* 'Challenger,' Zoology, vol. vii., 1883, part xix.

† 'Ent. Monthly Mag.,' vol. xxix., 1893, pp. 227–232.

segment two and a half times as long as the distal (figs. 1, 11). Abdomen of male with the 8th segment slightly asymmetrical (figs. 13, 14, 15), the "horns" being both inclined towards the left, so that while the right horn is closely applied to the 9th segment, the left is somewhat divergent from the axis of the body; both horns are falcate at the tip.

Habitat:—Coasts of Ceylon. Old Dutch Modragam Paar, numerous males and females; Galle Bay, two males and one female; off Mutwal Island, Gulf of Manaar, two females; off Manaar Island, several young specimens.

This species is most nearly allied to *H. flaviventris*, Eschs., of all members of the genus hitherto described. It differs from that species principally in the shape and in the slight asymmetry of the "horns" of the 8th abdominal segment of the male. The form of this segment in the present insect shows an interesting stage of transition between the symmetrical condition found in the great majority of the species of *Halobates* and the excessive irregularity of *H. micans*, Eschs. (*H. wüllerstorfii*, Frauenf.), in which the left horn of the segment projects almost at right angles to the axis of the body.

In colour *H. herdmani* resembles the other species of the genus. The dorsal and lateral surfaces appear deep blue-black when wet, and ashy grey (owing to the dense pubescence) when dry. On the head are the usual pair of orange triangular marks, while the feelers and legs are black. The thoracic sternum is dark centrally, showing only two pale elongate patches towards the lateral sutures (fig. 14) close to the bases of the hind legs. The abdominal sterna are mostly pale, but they appear dark laterally and along their hinder borders; the 1st abdominal segment, on which is the opening of the repugnatorial glands, is deep brown.

The sutures, partially marking the junctions of the anterior abdominal terga, can be unusually well seen in this species (figs. 1, 2), and the male has a median longitudinal suture extending from the front of the mesothorax to the hinder edge of the 2nd abdominal segment. The recognition of the transverse dorsal sutures reminds us that though the abdomen is indeed much reduced in this genus, as compared with most of its fresh-water allies, yet the peculiar modification of the body is principally due to the abnormal extension of the mesothorax, and to the backward growth of that segment and of the metathorax on either side of the anterior abdominal segments.

Fore Legs.—The fore legs of the various species of *Halobates* have been frequently described and figured, affording as they do excellent diagnostic characters. A few details are, however, worthy of especial notice. The tarsal segments in the present species are longer and more slender in the female (fig. 9) than in the male (figs. 5, 6). The whole of the limb is covered with a fine pubescence, but on the upper surface a number of short, stout spines are interspersed among the delicate hairs (fig. 5), these spines being especially strong in the male and being absent from the under surface of the foot in both sexes (figs. 6, 9). At the end of the shin, however,

on this surface are a number of long, stiff bristles lying in the shallow groove close to the joint with the proximal tarsal segment. BUCHANAN WHITE drew attention to the curious row of stout, blunt hairs or spines on the edge of the inner apical prominence of the shin. In the present species there are more than twenty of these on the male's leg (figs. 5*a*, 7), and five on the female's (figs. 9*a*, 10). The arrangement of these structures is highly suggestive of a stridulating organ, and it is probable that they form an instrument for rasping along a "comb" formed by a row of sharp, strong spines (figs. 5*b*, 6*b*, 8, 9*b*), about ten in number, and increasing in length as the tip of the shin is approached. This "comb" is situated on the upper face of the apex of the shin. The "file" of each foot must of course play on the "comb" of the other—quite a possible arrangement when we remember that the fore legs in these insects are very mobile, and that the feet can be crossed over each other in front of the head. Similar structures occur towards the distal end of the shin in the allied reef-haunting genus *Hermatobates* (CARPENTER).*

Male Abdominal Segments.—As mentioned above, the present species is characterised by a comparatively slight asymmetry in the "horns" of the 8th segment in the male's abdomen (figs. 13, 14, 15); while the right horn is closely applied to the globose 9th (genital) segment, the left horn is directed laterally outwards at a slight angle. Each horn is expanded at the tip into a falcate process with a few stout black spines (fig. 15). In the allied *H. flaviventris*, ESCHS., the horns are symmetrical,† and each has a somewhat pointed process on the outer margin about the middle of its length, tapering at the tip. It is of interest to remember that *H. flaviventris*, to which the present species is most nearly allied, has been recorded from the Indian Ocean near Ceylon, while *H. micans*, the species with the very divergent "horn," inhabits all the warmer oceans. It is exceedingly likely that with these insects, as with others, our specific distinctions will become less definite as our knowledge of the possible variations in structure increases.

Female Abdominal Segments and Ovipositor.—It is rather remarkable that while the hindmost segments of the male *Halobates* have attracted much attention from entomologists, the corresponding region in the female has been neglected. This is probably because, in preserved specimens, the lateral sclerites of the 8th segment (figs. 16, 17, 18, *a*) are usually in close contact ventrally, and

* 'Sci. Proc. R. Dublin Soc.' vol. vii., 1891 (plate xii., fig. 6). For descriptions of other stridulating organs in the *Hemiptera* see HANDLIRSCH, 'Ann. Naturhist. Hofmus. Wien,' vol. xv., 1900, pp. 127–141; KIRKALDY, 'Journ. Quekett Micros. Club' (2), vol. viii., 1901, pp. 33–46; and BERGROTH, 'Proc. Zool. Soc.,' vol. ii., 1905, pp. 146–154.

† BUCHANAN WHITE states (*loc. cit.*, p. 33) that "in all the other species examined [except *H. wullerstorffi* = *micans*] both horns are symmetrical," though his figure of *H. flaviventris* from the dorsal aspect (plate ii., fig. 2*g*) shows the left horn only visible, and slightly divergent as in the present species. NASONOV, however, in his figure of *H. flaviventris*, var. *kudrini* ('Entomological Researches,' 1893—in Russian—Warsaw, 1897, fig. 14), shows the genital segments of the male from beneath, and the two horns appear perfectly symmetrical.

the ovipositor retracted beneath them. BUCHANAN WHITE remarks that "the ovipositor appears to consist of four valves," and NASONOV in his figures* shows only two pairs of processes (gonapophyses). Several of the females in the present collection have, fortunately, the ovipositor well extended, and it is not difficult to see that the three pairs of processes usual in the insectan ovipositor are present.

In a specimen with the ovipositor thus extended the two lateral sclerites of the 8th segment (figs. 16, 17, 18, *a*) are widely separated, and a transversely striated, flexible cuticle (figs. 17, 18, *b*) is seen to occupy the ventral region of the abdomen behind the 7th sternite. As this cuticle must be folded between the sclerites of the 7th and 8th segments when the ovipositor is retracted, and as it lies in front of the genital opening (figs. 17, 18, *c*), it is to be regarded as an intersegmental membrane, while the small sclerites that are visible behind it—a triangular pair (fig. 19, *d*) supporting the bases of the anterior processes of the ovipositor, and a very slender pair (figs. 17, 18, d^1) continuous with the chitinous rim that lies posterior to the genital aperture, must represent the 8th sternite. In front of the genital aperture the intersegmental membrane projects in the form of a hood (figs. 17, 18, c^1) with a pointed and forwardly-directed process.

The anterior pair of gonapophyses (figs. 17, 18, 19, *e*) are attached to the reduced 8th abdominal sternite, as previously mentioned. Each of these processes is broad at the base, which is pale and feebly chitinized except at the outer margin, where a firm dark ridge is developed. Distally the process becomes tapering in form, brown in colour, firm and well chitinized in texture, and beset with rows of prominent bristles. In addition to this main axis of the process there is a small delicate internal limb (figs. 17, 18, e^1) which lies close to the genital opening.

Beneath the lateral sclerites of the 8th segment there lies on each side an elongate sclerite (figs. 17, 19, *f*), whose shape and relations become evident only when the overlying 8th segment has been removed. Then it is clear that these sclerites (*f*) belong to the 9th segment. At its dorsal extremity each is produced into a dark, prominent knob, which lies just anterior to the small "tail-segment" (figs. 16, 17, 19, *j*), while at its ventral end each supports the two posterior gonapophyses. The outer pair of these processes (figs. 16, 17, 18, 19, *g*) are strong and flexible at the base, while distally each is produced into a straight, firm "guide" on which the inner process slides to and fro. When the ovipositor is extended, the tips of these hinder outer processes do not reach quite as far as the tips of the anterior processes. The inner posterior processes (figs. 16, 17, 18, 19, *h*) are very long, slender, and flexible at the base, but distally they become somewhat broad and flat, and terminate in a hook-like tip beset with fine hairs. The gonapophyses of the 9th segment remain free from one another, except for an extensive pale membrane (figs. 16, 17, 18, *i*) which is stretched between them when the ovipositor is extended. This membrane terminates in a pair of short pointed prominences.

* *Loc. cit.*, figs. 11, 12.

When the ovipositor is retracted, the slender basal portions of the hinder gonapophyses, especially of the inner pair, become bent almost in a semicircle (fig. 19), while the tips of the processes are withdrawn dorsalwards and fit just in front of the anal segment, so that they can be covered by the lateral sclerites of the 8th segment, meeting in the mid-ventral line.

It has been shown by HEYMONS* that in *Naucoris* and other Hemiptera the ovipositor is composed of the three pairs of gonapophyses usual in insects, not, as supposed by VERHOEFF,† of two pairs only. *Halobates* has therefore an ovipositor in which can be recognised all the parts typical of its order and class. But the processes of the 8th segment in *Halobates* recall by their appearance the outer pair of the 9th segment in *Naucoris* and in many other insects; while the latter pair, instead of being as is usual blunt and hairy, form in *Halobates* stiff, rod-like "guides" for the inner pair of the 9th segment. These last-named processes, which in most hemipteran and hymenopteran ovipositors are closely approximated or even fused together, remain apart in *Halobates*. Thus the ovipositor has here a somewhat primitive arrangement, intermediate between the simple condition found in the Orthoptera and the specialised form to be observed in such Hemiptera as the Cicadidæ.

The egg of *Halobates*, which is of large size, must be held between the processes of the 8th segment and the inner processes of the 9th segment. These are the processes that hold the eggs in insectan ovipositors generally.

If the narrow sclerites above-mentioned (figs. 17, 19, *f*) represent the skeleton of the 9th abdominal segment, then the "tail-segment" (figs. 16, 17, 19, *j*) (with which the large dorsal anchor-shaped sclerite in the male presumably corresponds) belongs to the 10th segment, and the small sclerite below it bounding the anal opening (figs. 16, 17, 19, *k*) represents the 11th segment. And thus all the segments of the typical insectan abdomen can be recognised in these remarkable marine bugs, in spite of the many special adaptations that they have undergone in correspondence with their wonderful manner of life.

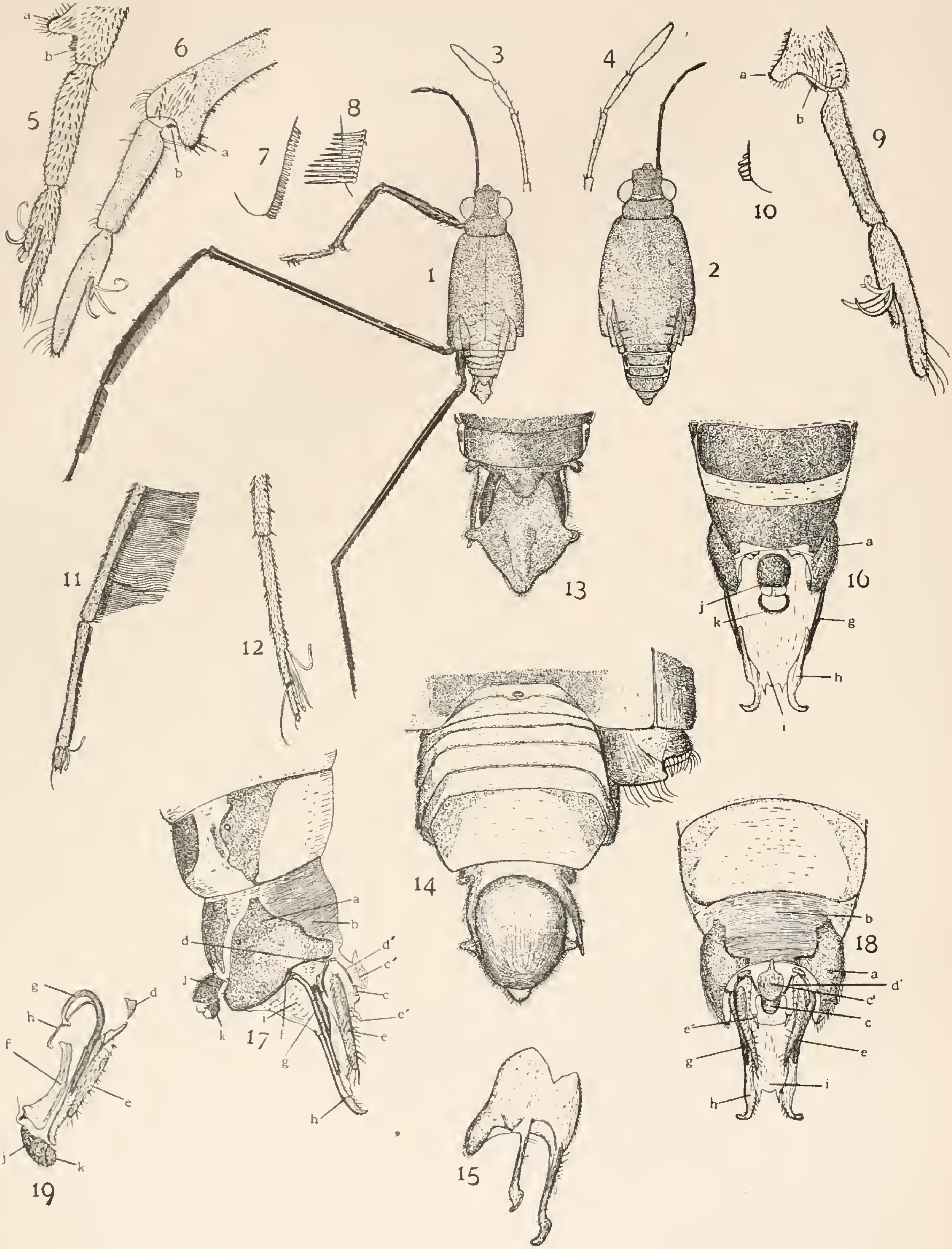
* 'Nova Acta Acad. Leopold Carol.,' lxxiv., 1899, No. 3.

† 'Entom. Nachrichten,' xix., 1893, pp. 369–378.

EXPLANATION OF PLATE.

Fig. 1.	*Halobates herdmani,*	male, dorsal view. × 8.
,, 2.	,,	female ,, ,, × 8.
,, 3.	,,	male, left feeler (terminal segments). × 20.
,, 4.	,,	female, right ,, ,, ,, × 20.
,, 5.	,,	male, apex of shin, with tarsal segments. Upper aspect. × 40.
,, 6.	,,	,, ,, ,, ,, Lower ,, × 40. *a,* "file," *b,* "comb" of stridulating organ.
,, 7.	,,	male, "file" of stridulating organ. × 250.
,, 8.	,,	,, "comb" ,, ,, × 250.
,, 9.	,,	female, apex of shin, with tarsal segments. Lower aspect. × 40. *a,* "file," *b,* "comb" of stridulating organ.
,, 10.	,,	female, "file" of stridulating organ. × 250.
,, 11.	,,	male, tip of proximal tarsal segment with distal segment of intermediate leg. × 40.
,, 12.	,,	male, tip of shin with tarsal segment of hind leg. × 40.
,, 13.	,,	,, dorsal view of "genital" segments. × 40.
,, 14.	,,	male, ventral view of abdomen, showing hinder edge of thoracic sternum and coxa of left hind leg. × 40.
,, 15.	,,	male, 8th abdominal segment isolated and viewed obliquely from the ventral aspect. × 40.
,, 16.	,,	female, dorsal view of end of abdomen with extended ovipositor. × 40.
,, 17.	,,	,, lateral ,, ,, ,, ,, ,, × 40.
,, 18.	,,	,, ventral ,, ,, ,, ,, ,, × 40.
,, 19.	,,	,, lateral view of retracted ovipositor, as seen after removal of the lateral sclerites of the 8th segment. × 40.

In figs. 16 to 19: *a,* lateral sclerites of 8th abdominal segment; *b,* intersegmental membrane; *c,* genital aperture; c^1, "hood" in front of ditto; *d,* triangular, and d^1, slender sclerites of 8th sternum; *e,* anterior gonapophyses; e^1, slender internal limb of ditto; *f,* sclerite of 9th abdominal segment; *g,* outer posterior gonapophyses; *h,* inner posterior gonapophyses; *i,* membrane extending between gonapophyses; *j,* 10th abdominal segment; *k,* anal segment.



GHC.

HALOBATES HERDMANI, n. sp.

REPORT

ON THE

LEPTOSTRACA, SCHIZOPODA AND STOMATOPODA

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

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[WITH THREE PLATES.]

THE collections of these three groups of Crustacea Malacostraca, made by Professor HERDMAN and Mr. HORNELL in Ceylon, and kindly entrusted to me for examination, are small both in number of species and, with one or two exceptions, in individuals as well. Nor is the number of new forms by any means remarkable or at all out of proportion to the total number of species, only two hitherto undescribed forms, both in the Stomatopoda, having been met with in the collection. Still, the material is not without interest, at least six very rare species being comprised therein; this afforded an opportunity for completing or adding to the published descriptions, or of increasing materially the known geographical range.

The LEPTOSTRACA are represented by a single species, which differs so slightly from the well-known and widely distributed northern form, *Nebalia bipes*, that I cannot consider it as a distinct species or even variety.

The SCHIZOPODA are on the whole distinctly disappointing. Five species are represented in the collection; but as three of these occurred only in tow-net gatherings taken on the outward journey to Ceylon, only two can therefore be regarded as belonging to the Ceylon fauna. One of these, *Euphausia latifrons*, appears to be an abundant form, but of the other, a Mysid, *Siriella paulsoni*, only a single specimen is present.

So little is known of tropical Mysidæ, that one had hoped that the collections made by Professor HERDMAN in Ceylon would have added considerably to our knowledge, especially as the material of the other groups of Crustacea, more notably the AMPHIPODA, ISOPODA, and CUMACEA, has been found to be so rich in the number of species, both described and new. Still, as, so far as I am aware, no SCHIZOPODA have previously been recorded from Ceylon waters, the present collection, though small, provides a first contribution to our knowledge in this respect.

To judge from the contents of the stomach of a ray, *Dicerobatis ergoodoo*, which contained several hundred specimens of *Euphausia latifrons*, the Euphausians in the tropics, equally with those of more temperate climes, are economically of primary importance as fish-food, an importance which can scarcely be over-estimated.

With the STOMATOPODA, Professor HERDMAN was distinctly more successful, ten species of adult and ten types of larvæ being present in the collection. Remembering the difficulty which always attends the capture of adult Stomatopoda of any kind, the results obtained must be regarded as highly satisfactory considering the limited time at Professor HERDMAN'S disposal. Five species are added to the fauna of Ceylon, two of which, *Gonodactylus herdmani* and *G. acanthurus*, are new to science, both possessing features of great interest.

Species of adult STOMATOPODA have been recorded from Ceylon by HELLER (1868), MIERS (1881), MÜLLER (1887), and HENDERSON (1890 and 1893). The full list is as follows, with the names of the recorders :—

Squilla nepa [HELLER, HENDERSON, 1890].
S. oratoria [HELLER].
S. scorpio [HENDERSON, 1890].
Lysiosquilla maculata [HENDERSON, 1890].
L. saracinorum [MÜLLER].
Pseudosquilla ciliata [MÜLLER, HENDERSON, 1890].
Gonodactylus chiragra [MÜLLER, HENDERSON, 1893].
G. glabrous [HENDERSON, 1893].
G. graphurus [MÜLLER, MIERS, HENDERSON, 1890].
G. demani [HENDERSON, 1893].
Odontodactylus scyllarus [MÜLLER].
Protosquilla trispinosa [HENDERSON, 1893].
P. trispinosa, var. *pulchella* [HENDERSON, 1890, MIERS].
P. stoliura [MÜLLER].
P. ectypa [MÜLLER].

Of this list, *Squilla oratoria*, as recorded by HELLER, is regarded by MIERS as synonymous with *S. nepa*. This leaves a total of thirteen species and one variety of Stomatopods already known from Ceylon. To these must now be added the following five species :—

Squilla raphidea, FABRICIUS.
Odontodactylus brevirostris (MIERS).
Gonodactylus herdmani, n. sp.
G. acanthurus, n. sp.
Protosquilla spinosissima (PFEFFER).

The larvæ in this collection which could be referred to already described forms are recorded below under the names given to them by their describers. Those which do not appear to have hitherto been met with, or at least not named, are not given new specific designations, as I am of the opinion that such a proceeding in connection with

larval forms is not desirable. They are, however, described and figured in the hope that they may be recognised in future collections, and their life-history more fully traced.

In the preparation of this paper I have been kindly aided by Dr. NOBILI, of Turin, and Professor PFEFFER, of Hamburg, with information on various species, and to these gentlemen I desire to express my grateful thanks. I am especially indebted to Dr. W. T. CALMAN for his kindness and help while at the British Museum, and for very valuable assistance with the literature of the subject.

I.—LEPTOSTRACA.

FAMILY: NEBALIIDÆ.

Nebalia bipes (FABRICIUS).

Localities:—

Cheval Paar, February, 1902, 5 to 8 fathoms. Five.

Washings from pearl oysters, Ceylon. Thirteen.

Periya Paar, February 5, 1902, tow-net at night, surface. Few.

The specimens of *Nebalia* obtained by Professor HERDMAN in Ceylon may all, I think, with certainty be referred to the type species, though differing from northern examples of that species in one or two minor points. They do not fall into any of the numerous varieties of *N. bipes* recently indicated by THIELE (1904), but I do not propose to designate them by a separate varietal name, because the differences are too slight to deserve such an honour. Insignificant as these differences are, they serve to bring still closer together the two supposedly distinct species of this genus, *N. bipes* and *N. longicornis.* The characters which serve to distinguish the two latter species from each other have recently been defined by THIELE (1904). Briefly, *N. bipes* may be distinguished from *N. longicornis* (1) by the size of the rostrum, which in the former is much longer proportionately to the breadth than in the latter; taking the breadth of the rostrum as unity, its length in *N. bipes* is 2·62, and in *N. longicornis* 1·75;* (2) by the armature of the fourth joint of the peduncle of the first antenna. This joint in *N. bipes* is armed on its outer edge with at least three (sometimes as many as eight, *cf. N. bipes*, var. *valida*) spines and five or six setæ, whereas in *N. longicornis* there is only one spine and seven or eight setæ.

In *N. bipes* from Ceylon the rostrum is in all the specimens about two and a third times as long as broad, and shaped on the whole as in THIELE'S fig. 70. The fourth joint of the peduncle of the first antenna bears on its outer edge two spines (without exception in all of the eighteen specimens) and four or five setæ. The characters, therefore, of Ceylon *N. bipes* are exactly intermediate between those of *N. bipes typica* and *N. longicornis.*

The specific differences between the two latter species as given by THIELE are very

* These figures are taken from THIELE'S drawings, 1904, plate iv., figs. 66 and 70.

slight in themselves, and in the light of Ceylon specimens of the former species would appear to almost reach vanishing point.

The eye in the Ceylon examples has the sensory papilla well developed, while the fourth pair of pleopods does not appear to differ from those of typical specimens of *N. bipes*. *N. bipes* in one or other of its varieties is a very widely distributed form in the northern hemisphere. Since the examples noted by STEBBING from Sandal Bay, Lifu, and New Britain are more properly, according to THIELE, referable to *N. longicornis*, Ceylon is the southernmost point from which *N. bipes* has as yet been recorded.

II.—SCHIZOPODA.

FAMILY: EUPHAUSIIDÆ.

Euphausia mutica, HANSEN (1905).

E. pellucida (*pars*), SARS (1885).

Localities:—

Indian Ocean, south of Sokotra, surface tow-net. Three specimens of 10 millims.; and five, 6 millims and under.

Indian Ocean, between Sokotra and the Laccadives, surface tow-net. Forty, 5 to 15 millims.

Indian Ocean, between the Laccadives and Ceylon, surface tow-net. Two, 11 millims.

This species was not actually met with in Ceylon waters, but was captured on the outward journey there by means of tow-nets. All the specimens were taken at the surface in crossing the Indian Ocean from Sokotra to Ceylon.

This species has only recently been founded by HANSEN for specimens formerly referred by SARS to *E. pellucida*, DANA, in which he also included *E. mülleri*, CLAUS, and *E. bidentata* (M. SARS), as synonyms. HANSEN (1905), however, rejects *E. pellucida*, DANA, as unrecognisable from DANA's descriptions and figures, and makes *E. mülleri* the type of the genus, with *E. bidentata* as a synonym. From *E. mülleri*, *E. mutica* is chiefly distinguished by having the leaflet on the basal joint of the antennular peduncle bidigitate instead of multidigitate. This latter character is also shared by *E. recurva*, HANSEN, and *E. brevis*, HANSEN. *E. mutica*, *E. recurva*, and *E. brevis*, which all have two lateral denticles on the carapace, are separated from each other, by HANSEN, on the characters of the armature of the second joint of the antennular peduncle and the shape and direction of the antennular leaflet.

Small examples of *E. mutica* in this collection, 5 millims. in length, while in other respects agreeing fairly well with larger examples, only possessed a single lateral denticle on the carapace. This is quite in accordance with the fact that the second denticle is of late appearance, and SARS (1885), moreover, describes and figures a young Euphausian, 7 millims. long, which he refers to *E. pellucida*, and which has the second denticle on the carapace still undeveloped.

Euphausia mutica is, according to HANSEN, known from the tropical and southern Atlantic, Red Sea, Indian Ocean, and various parts of the North Pacific.

Euphausia latifrons, G. O. SARS.—Plate I., figs. 1 and 2.

Localities :—

South end of Red Sea, surface tow-net. Three, 3 to 5 millims.

Indian Ocean, between Sokotra and the Laccadive Islands, surface tow-net. One, 8 millims.

Off Kalpentyn Island, Ceylon, February 3, 1902, surface tow-net all night and early morning. Fourteen, 8 to 10 millims.

Watering Point, Galle, February 15, 1902, surface tow-net. One, 7·5 millims.

Off Mutwal Island, Ceylon, March 19, 1902, surface tow-net. One, 8 millims., and two larvæ.

North-east of Chilaw Paar, Ceylon, March 20, 1902, surface tow-net. Two, 4 and 6 millim.

Periya Paar, November 13, 1902, from stomach of a ray, *Dicerobatis ergoodoo*. Several hundreds, 8 to 10 millims.

The *carapace* is about half as long as the pleon, and has a single lateral denticle placed near the posterior end of its inferior margin just in front of the luminous organs of the penultimate thoracic limbs. It is produced in front into a squarely truncate or slightly emarginate rostral projection, the lateral angles of which are somewhat acutely pointed. The antero-lateral corners are pointed, and there is no very prominent dorsal keel.

The *segments of the pleon* decrease in depth posteriorly. The first five are subequal in length, while the sixth is about one and a half times as long as the preceding segment and has its posterior median dorsal border very slightly acuminate. The preanal spine is well developed, curved and simple. The epimera of the first five segments are rounded, those of the last segment slightly acuminate.

The *eyes* are rather small with the pigment black.

The *antennular peduncle* (figs. 1 and 2) is rather stout, with the basal joint slightly longer than the terminal two combined. The outer distal corner of the basal joint is produced into a short spine, while its inner distal margin bears about six long plumose setæ which interlock with those of the other peduncle. On the dorsal surface there is a leaflet running obliquely across the distal end of the basal joint. The leaflet is strongly curved, and the external half of its margin is divided up into eleven acutely pointed lappets. The external part of the leaflet overhangs the spine on the outer distal corner of the basal joint. The second joint of the peduncle is longer than the third.

The *antennal peduncle* is about as long as the scale, and has the terminal joint almost as long as the basal two combined.

The *antennal scale* extends to the distal end of the second joint of the antennular

peduncle. It is about four times as long as broad, with its outer margin slightly curved and terminating in a distinct though feeble spine. The apex of the scale is broadly rounded, while its basal spine is short and smooth.

The *mouth parts and thoracic limbs* offer no points of special interest.

The *telson*, including the subapical spines, is about as long as the last two segments of the pleon combined. It is narrowly lanceolate in shape, with the portion beyond the insertion of the subapical spines suddenly constricted and acutely pointed. Its dorsal surface bears five pairs of dorsal denticles on its distal half. The subapical spines have rather broad insertions and their inner distal edge bears five small denticles.

The *uropods* have the plates subequal in length and very slightly shorter than the telson. The inner plate is much narrower than the outer, which terminates in a minute spine on its outer edge.

Length of the largest specimen 12 millims.

The numerous specimens in this collection which I refer to this species differ from the descriptions and figures of SARS in four points, (1) in the presence of a lateral denticle on the carapace, (2) in the very much more digitate form of the membranous leaflet of the antennules, (3) in the presence of five instead of three pairs of denticles on the telson, (4) in the greater relative development of the uropods. The last three points of difference may be accounted for by the difference in size and age of SARS' specimens and my own. SARS' descriptions and figures were taken from a specimen 7·5 millims. long, while the above description is of a specimen 12 millims. long. The first of the above-mentioned differences is due to an error on SARS' part.

The examination of the type of *E. latifrons*, for which I am greatly indebted to Dr. W. T. CALMAN, reveals the presence of a small but quite distinct spine on the lateral margin of the carapace just in front of the luminous organ of the penultimate thoracic limb. The type specimen, according to information kindly given to me by Dr. CALMAN, is one of those from Port Jackson, Australia, mentioned by SARS in his 'Challenger Report,' p. 96, as having come to hand late. It is, therefore, not the specimen figured or described. It is not quite as large as some of the Ceylon specimens, but considerably more developed than the one SARS figured. The leaflet on the basal joint of the antennular peduncle of this specimen is divided up distally into nine rather short lappets, being thus intermediate in development between SARS' figure and my own.

STEBBING (1905), in recording this species from S. Africa, notes the presence of a lateral denticle on his specimens, and is of opinion that it probably becomes obsolete in quite adult examples.

Euphausia latifrons is the smallest known species of the genus, and is at once distinguished from all other described species by the peculiar form of the rostral projection.

Distribution: -Australian seas and East Pacific near the Phillipine Islands ('Challenger'); South Africa (STEBBING).

Its occurrence at Ceylon thus fills up a gap in the distribution of the species in the Pacific. Round Ceylon it would appear to be a very abundant species, judging from the contents of the stomach of a ray, *Dicerobatis ergoodoo*, which contained several hundred specimens. All the other specimens were taken at the surface of the sea, though its occurrence in the stomach of a bottom-living fish like a ray would seem to indicate that the species does not always adopt an entirely pelagic habitat. The depth over which the species was captured by tow-nets in no case exceeded 20 fathoms.

Nematoscelis microps, G. O. SARS (1885).

N. rostrata, G. O. SARS (1885). **N. mantis**, CHUN (1896). **N. microps**, HANSEN (1905).

Locality:—Off Mutwal Island, Ceylon, March 19, 1902, surface tow-net. Two, 3·5 millims.

HANSEN (1905) has recently demonstrated that *Nematoscelis rostrata* is in reality only the young of *N. microps*, and I here adopt his view of the matter.

The two small Ceylon specimens agree very well with the description and figures given by SARS of the Cyrtopia larva of *N. rostrata*. The rostrum is large and well developed, and the lateral spine on the carapace very prominent. Though the specimens measure only 3·5 millims. in length, the long leg is already well developed and measures about 2 millims. in length. It is too stoutly built to admit of referring the specimens to *N. tenella*. In other points, such as the general proportions of the body, the Ceylon specimens are in harmony with SARS' figures.

N. microps was taken by the "Challenger" at several stations in the tropical and subtropical Atlantic Ocean and in the Pacific to the north of New Guinea. It has since been recorded from the Mediterranean by CHUN, and from the tropical Atlantic Ocean off America and Africa by ORTMANN and HANSEN respectively.

FAMILY: MYSIDÆ.

Siriella paulsoni, KOSSMANN.—Plate I., figs. 3 to 7.

S. jaltensis, PAULSON (1875), *nec*, CZERNIAVSKY. **Siriellides paulsoni**, CZERNIAVSKY (1880).

Locality:—Pearl Banks, Cheval Paar, March, 1902, 8 fathoms. One female, 12 millims.

The general form of the body is robust and rather stoutly built.

The *carapace* is shorter than the pleon and of equal breadth throughout. It is produced in front into a short acutely pointed rostrum.

The *pleon* has the first segment slightly longer than the next four, which are subequal in length. The sixth segment is about one and a half times as long as the fifth.

The *eyes* are large and globose, not quite reaching the distal end of the basal joint of the antennular peduncle. The pigment is black.

The *antennular peduncle* (fig. 4) is rather long and stoutly built. The basal joint is longer than the remaining two combined. The second joint is quite short and has its outer edge armed with short plumose setæ. The third joint is longer than the second. All three joints have a plumose seta on their inner distal corners.

The *antennal peduncle* is rather long and slender, with the penultimate joint about three times as long as the terminal one.

The *antennal scale* (fig. 4) extends almost to the distal end of the antennular peduncle and is about three times as long as broad. Its outer margin is entire and terminates in a strong spine, beyond which the evenly rounded apex of the scale projects for a little distance.

The *mouth parts*, in so far as they could be studied in the single available specimen, agreed well with KOSSMANN's figures.

The *first thoracic limbs* (maxillipedes) (fig. 5) are rather short when compared with the same appendage in *S. thompsoni*. The merus is longer than the carpus, the propodus is small and the nail distinct and longer than the propodus. The whole limb is moderately well armed on its inner edge with short plumose setæ.

The *second thoracic limbs* are missing in the specimen.

The *remaining thoracic limbs* (fig. 6) are somewhat slender and elongate. The tarsus is about as long as the merus and distinctly two-jointed, the first joint shorter than the second one. The nail is distinct and long, and the whole limb well armed with simple setæ, with a bunch of plumose setæ at the basal part of the nail.

The *exopods* of all the thoracic limbs are well developed, and have the outer distal corner of the expanded basal joint slightly acuminate. The flagelliform part is composed of ten joints.

The *pleopods* are of the usual type found in the females of this genus.

The *telson* (fig. 7) is about one and a half times as long as the last segment of the pleon. It is narrowly linguiform and tapering in shape with a prominent constriction at about one third of its length from the base. The apex is armed with a pair of long spines, between which are a pair of median setæ and three small equal-sized spinules. The sides below the constriction are armed with about 28 spines arranged in series of five distally, and three and four proximally. The proximal spine of each series is the shortest, the succeeding spines gradually increasing in length. Above the constriction the lateral margins are armed with three stout spines, longer than the spines arming the distal part of the margins.

The *inner uropod* is about one and a sixth times as long as the telson, narrow and having about 45 spines on its inner margin, the spines commencing at the inner posterior corner of the otocyst and extending to the tip. The spines are arranged in series of sometimes two and sometimes three, the most posterior spine nearly as long as the terminal spines of the telson. The otocyst is well developed.

The *outer uropod* is a little longer than the inner and much broader, the terminal joint being about one quarter of the length of the proximal one, the latter armed on the distal two thirds of its outer margin with 15 strong spines increasing in length posteriorly.

Length of an ovigerous female 12 millims.

The above description is based on the single Ceylon specimen in this collection, which I refer to this species. The male is as yet unknown. Professor PAULSON (1875) first described this species, though he referred his specimens at the time to *S. jaltensis*, CZERNIAVSKY. KOSSMANN (1880), who had a much larger specimen of what he believed to be PAULSON's species at his disposal, recognised that it differed rather markedly from *S. jaltensis*, and, therefore, re-described it, with figures, under the name *S. paulsoni*. CZERNIAVSKY (1880) likewise came to the conclusion that *S. jaltensis*, PAULSON, was not the same as his species, and, apparently unacquainted with KOSSMANN's earlier paper, fortunately also re-named it *S. paulsoni*. He had, however, no specimens, and drew up his diagnosis entirely from PAULSON's work.

Though both CZERNIAVSKY's and KOSSMANN's descriptions are imperfect in many points, they only differ in one important detail from the Ceylon example, namely, in the number of spines on the outer margin of the first joint of the outer uropod. CZERNIAVSKY gives the number as seven, KOSSMANN figures eight, while the Ceylon specimen has fifteen. This great difference may, I think, be explained by the difference in size of the individuals from which the various descriptions were drawn up. CZERNIAVSKY's description was based on PAULSON's specimen, 4 millims. in length; KOSSMANN's example was 8·5 millims., while the Ceylon one is 12 millims. The spinulation of the telson and uropods is known in other species of the group to vary with the size of specimens. In all other respects the present example agrees in the main with KOSSMANN's figures. *S. paulsoni* approaches nearest to *S. denticulata*, G. M. THOMPSON, among all the species of *Siriella* which have been described, but differs from the latter (1) in the length and proportion of the joints of the antennal peduncle; (2) in the deviating form of the antennal scale; (3) in the presence of spines on the lateral margins of the telson above the constriction; (4) in the much larger number of spines on the inner uropod. From the three Pacific species of the genus—*S. gracilis*, *S. thompsoni* and *S. indica*—*S. paulsoni* may be at once distinguished by having the outer uropod longer than the inner, and in having many more spines on the outer edge of the former. Previous to Professor HERDMAN's capture of this species in Ceylon it was only known from the Red Sea. Its geographical distribution has thus been considerably extended. As far as I am aware, it is the first Mysid ever recorded from Ceylon.

Haplostylus erythræus, KOSSMANN (?).

Locality :—South end of Red Sea, surface tow-net. One female, 5 millims.

In consequence of its small size and damaged condition the absolute identity of

this specimen is a matter of some doubt. A description of the specimen is therefore given.

The *carapace* has the rostral projection short and bluntly rounded. It is without any trace of dorsal lobes on its hinder margin, which is slightly emarginate.

The *pleon* has the sixth segment about one and a half times as long as the preceding one, which shows no trace of a median posterior dorsal spine.

The *antennular peduncle*, which is only slightly longer than that of the antenna, has two small spines on the outer margin of the second joint.

The *antennal scale* is very short, scarcely reaching beyond the distal end of the basal joint of the antennular peduncle. Its outer margin is entire and terminates in a very strong spine. The apex of the scale does not project beyond the tip of the spine.

The *telson* is as long as the last segment of the pleon and cleft at its apex, the cleft, as usual in this sub-family, being serrated. The lateral margins bear six long and stout spines.

The *uropods* are both slightly longer than the telson, the inner a very little longer than the outer. The outer uropod has eleven strong spines on the outer margin, while the inner bears five spines on its internal margin.

Length, 5 millims.

It is probable that the above specimen belongs to *H. erythræus*. As just described, it differs from *H. normani* in the antennal scale, which has a stronger terminal spine and the apex not produced beyond the spine, and also in having a much blunter rostral projection. The males further differ from those of *H. normani* in having the inner branch of the third pleopod in the male quite absent.

H. erythræus is only known from the Red Sea, where both Kossmann's types and the above specimen were obtained.

III.—STOMATOPODA.

Family: SQUILLIDÆ.

Squilla raphidea, Fabricius.

Locality:—South-west part of Palk Bay, off Adam's Bridge and Rámésvaram Island, 7 to 9 fathoms. One male, 125 millims.

This specimen differed from large examples of this species which I examined in the British Museum in having the lateral processes of the fifth thoracic somite obtuse instead of acutely spinous.

Distribution:—*S. raphidea* has a general Indo-Pacific distribution, though not previously recorded from the coast of Ceylon.

Squilla nepa, Latreille.

Locality:—South-west of Palk Bay, off Adam's Bridge and Rámésvaram Island, 7 to 9 fathoms. One male, 42 millims.

Distribution :—*S. nepa* has already been recorded from Ceylon by HELLER (1868). Its distribution is general over the whole of the Pacific and Indian Oceans.

Pseudosquilla ciliata (FABRICIUS), MIERS.

Locality :—Talaivillu Paar, off south end of Mutwal Island, 10 to 14 fathoms. One male, 33 millims.

It is interesting to note that this specimen agrees with BROOKS' West Indian examples in those points in which the latter differ from the Pacific ones. I have confirmed this by an examination of BROOKS' "Challenger" specimens. BORRADAILE (1900) has proposed the varietal name *occidentalis* for this form.

Distribution :—*P. ciliata* has been recorded from Ceylon once previously by F. MÜLLER (1887). It is another widely distributed Indo-Pacific form.

Gonodactylus chiragra (FABR.), var. *smithii*, POCOCK (1893).

Locality :—Muttuvaratu Paar, 45 to 50 fathoms, in cavities of coral. One female, 12 millims.

This specimen agrees very well with LANCHESTER'S var. *smithii* (A) (LANCHESTER, 1902), except that the spine on the median carina is perhaps not so well developed.

Distribution :—China seas (POCOCK, 1893); Funafuti and the Loyalty Islands (BORRADAILE, 1898); Malay Peninsula and the Maldives (LANCHESTER, 1902).

Gonodactylus chiragra (FABR.), var *incipiens*, LANCHESTER (1902).

Locality :—Trincomalee. One male, 18 millims.

The single specimen which I refer to this variety of the type species agrees with LANCHESTER'S var. *incipiens* (A) (1902, plate xxiii., fig. 10).

Distribution :—Funafuti (LANCHESTER).

Gonodactylus glabrous, BROOKS (1885).

Localities :—

Cheval Paar, 6 to 8 fathoms. One female, 46 millims.; one male, 16 millims.

Coral Reefs, Gulf of Manaar. Three females, 40, 30 and 15 millims.; one male, 34 millims.

Pearl Banks, Gulf of Manaar. Two males, 18 and 20 millims.

Entrance to Galle Harbour, 4 to 7 fathoms. One male, 18 millims.

South end of Periya Paar, 8½ to 13 fathoms. One female, 22 millims.; three males, 22, 20 and 17 millims.

South of Adam's Bridge, 4 to 40 fathoms. One male, 25 millims.

West and south-west of Periya Paar, 11 to 24 fathoms. One male, 20 millims.

West of Periya Paar, 17 to 24 fathoms. One female, 16 millims.

On weed-bearing oyster spat, south-east of Modragam, 4½ to 5½ fathoms. One male, 27 millims.

Aripu Reefs. Six males, 29, 26, 24, 20, 18 and 17 millims.; four females, 16, 15, 15 and 13 millims.

Galle Lagoon. Two females, 32 and 29 millims.

Galle, from cavity beneath Polyzoan crust. One female, 33 millims.

Off Mutwal Island, 10 to 14 fathoms. One female, 38 millims.; two males, 34 and 27 millims.

From the above list of captures it will be seen that this species is a very common one in Ceylon. In all, 33 specimens were captured, 19 of which were males ranging from 16 millims. to 34 millims. in length, and 13 females of from 13 millims. to 46 millims. in length. In no case did the depth of water over the ground on which they were taken exceed 24 fathoms. LANCHESTER (1902) in a survey of *G. chiragra* and the allied forms *G. glabrous* and *G. graphurus* expresses the opinion that the two latter species are in reality only varieties of the type species of the genus, and figures a series of telsons in support of this view, at the same time defining under separate varietal denominations a series of types leading from *G. chiragra* through *G. glabrous* to *G. graphurus*. The material in the present collection is by no means sufficient to attempt a discussion on the point raised by LANCHESTER, but its very uniformity has led me, at least for the present, to regard *G. glabrous* as a species distinct from *G. chiragra*, and constantly distinguished from the latter by the presence of two extra carinæ on the telson.

In only one specimen (not included in the above list of records, but referred to below) was any striking divergence in the form of the telson from that of the type to be noticed, and although it falls within one of the new varieties proposed by LANCHESTER, I regard it not as a definite varietal form, but as an individual abnormality.

It is true that the 33 specimens recorded above vary slightly among themselves in the relative tumidity of the carinæ of the telson, and in the absence from one or other of them of the terminal spines. But the difference between the extremes is at most slight, and the variation in any single instance (not even including the abnormality noted below) is not at all such as to cause any doubt for a single moment as to the validity of the specific separation of *G. glabrous* from *G. chiragra*.

LANCHESTER (1902) also notes on the telson of *G. glabrous* and *G. graphurus* the presence of two tubercles just beyond the distal end of the median carina. These two tubercles are present in all the Ceylon specimens, and also in BROOKS' type which I have examined at the British Museum.

A note on the colour of the Ceylon examples may be of interest. Several of the labels in the bottles had notes to the effect that the specimens contained therein were a vivid green colour when alive, and, indeed, a general bright green coloration seems to be the prevailing one in most of the specimens in the collection, many of which after three years' preservation still show strong evidence of this fact. All the specimens which appear to have been a uniform green when alive have four sharply defined though quite small dark green pigment spots, two on the sixth abdominal

segment and two on the telson. Those on the sixth abdominal segment are always placed between the intermediate and lateral carinæ, and those on the telson occupy a corresponding situation. The constancy of the association of these pigment spots with a uniform green colour in the specimens of *G. glabrous* in this collection was, indeed, striking. One or two specimens, however, appear to have been a more mottled colour, with a distribution of dark pigment corresponding more or less with that noted by BROOKS for his single type specimen. In these examples the four prominent pigment spots noted above were not present.

The single abnormal specimen to which reference has already been made was a female, 24 millims. long, taken at Trincomalee. It agreed almost exactly with LANCHESTER'S var. *segregatus* (B) = var. *affinis*, DE MAN. I prefer, however, to regard it as an abnormal *G. glabrous*, having the anterior portion of the intermediate carinæ obsolete.

Distribution :—This species has a generally wide distribution throughout the Indian and Pacific Oceans.

Gonodactylus, sp.

Localities :—

10 miles north of Cheval Paar, $7\frac{1}{2}$ to 9 fathoms. One, 11 millims.

Mudalaikuli Paar. One, 8 millims.

These two specimens, apparently belonging to the same species, are still post-larval in development. They probably belong to either *Gonodactylus glabrous* or *G. chiragra*. The telson agrees fairly well with that figured by BROOKS (1886, plate xvi., fig. 5) from a specimen which he attributes to some species of *Gonodactylus*. The dactylus of the raptorial claw in both specimens has a notch on the external margin near to the proximal end.

Gonodactylus herdmani, n. sp.—Plate I., figs. 8 to 10.

Locality :—Coral Reefs, Gulf of Manaar. Two females, 28 and 26 millims.

The *rostrum* (fig. 8) is of the *Protosquilla* type, with acutely produced median and antero-lateral spines. The median spine extends for rather more than half way along the eye. The antero-lateral spines are not so much produced.

The *carapace* is rectangular in shape, and of about equal width throughout. Its antero-lateral and postero-lateral angles are both evenly and broadly rounded.

The *last three thoracic segments* have their lateral parts rounded.

The first five abdominal segments are quite smooth all over, without carinæ or furrows of any kind, and with their postero-lateral angles rounded.

The *sixth abdominal segment* (fig. 9) bears on its dorsal surface four equidistant, perfectly smooth, narrowly oval, blunt carinæ. The central two of these carinæ are slightly posterior to the lateral ones. None of the carinæ end in spines. There is also a prominent, rather sharp carina on each side of this segment, quite near to the lateral margins and running into the postero-lateral angles.

The *telson* (fig. 9) has the six marginal spines well developed, unusually stout and blunt. In the largest specimen the lateral spines are almost obsolete. The submedian spines have a small movable spinule at their tips. There are *no* submedian, intermediate, or lateral denticles whatever. The dorsal surface of the telson bears a median, broadly oval carina, and a narrower and rather sharper carina on each side of it. There is also a prominent carina running down into the submedian and intermediate spines of the telson. The median carina bears at its posterior end a prominent blunt spine, with two small blunt tubercles on each side of it. The lateral carinæ and those which run into the intermediate and submedian spines of the telson are broken up into irregular tubercles. The lateral carinæ and those of the intermediate spines are composed of three of the tubercles, those of the submedian spines of four, which are moreover rounder and more regular in shape.

The *uropods* (fig. 10) are very powerfully built. The basal joint bears a very prominent dorsal ridge, which is continued down both joints of the exopod. These joints are therefore triangular in cross section. The first joint of the exopod bears eleven stout spines on its outer edge. Both paddles are unusually tough and chitinous, and quite unlike the flat, thin, membranaceous, lamella-like paddle usually met with in Stomatopods. Both have prominent dorsal ridges, and the inner one is of a most unusual scythe shape (fig. 10). De Man figures a similar paddle to the inner uropod of *G. drepanephorus*. The setæ are mostly broken off.

Length of the largest specimen 28 millims.

The *colour* of the preserved specimens is generally pale, but there is a distribution of black pigment, which is the same for both specimens. There are three prominent black pigment spots on the posterior part of the carapace, surrounded by numerous pigment flecks. Anterior to these, on each side, on the suture separating the median from the lateral parts of the carapace, is a small, narrowly oval, pigmented area. There is a prominent median black pigment spot surrounded by numerous pigment flecks in the ante-penultimate thoracic and first, third, fourth and fifth abdominal segments, while scattered pigment flecks are to be seen on the lateral parts of all the abdominal segments.

Four species of *Gonodactylus* have been described with a *Protosquilla*-like rostrum, viz., *G. acutirostris*, de Man, *G. drepanephorus*, de Man, *G. festæ*, Nobili, and *G. demani*, Henderson. From all these *G. herdmani* is at once distinguished by the unusual bluntness and stoutness of the marginal spines of the telson, the presence of a movable spinule at the tip of the submedian spines, and the *complete absence* of submedian, intermediate, or lateral denticles on the telson. Its nearest relative is *G. drepanephorus*, which has the same peculiar paddle to the endopodite of the uropods, but the spines on the telson of the latter are much sharper and more numerous than in *G. herdmani*, while the tubercles on the sixth segment end in spines, whereas in the present species these tubercles are quite smooth.

I have named the species in honour of its discoverer.

Gonodactylus acanthurus, n. sp.—Plate I., figs. 11 to 15.

Locality:—Muttuvaratu Paar, 45 to 50 fathoms. One female, 10 millims.; one male, 8 millims.

The *rostrum* (fig. 11) is of the usual *Gonodactylus* type, with a long acute median spine reaching very nearly to the cornea of the eye, and slightly produced, bluntly rounded antero-lateral angles.

The *carapace* is rectangular in shape, of about equal width throughout. Its antero-lateral and postero-lateral angles are rounded.

The *last three thoracic segments* have their lateral parts rounded.

The *first five abdominal segments* are quite smooth all over, without carinæ or furrows of any kind. The postero-lateral angles of the first four segments are broadly rounded, those of the fifth segment produced somewhat, but rounded at the tip.

The *sixth abdominal segment* has the postero-lateral angles ending in prominent spines. On its dorsal surface are six carinæ, the submedian and intermediate of which are narrowly oval, smooth, and blunt, the lateral ones being somewhat sharper and running into the spines of the postero-lateral angles. The submedian and intermediate carinæ do not terminate in spines.

The *telson* (fig. 14) has the six marginal spines well developed, long, acute, the laterals slightly curved. There are about nine submedian, two intermediate, and a single lateral, rather long and acute denticles on each side. The dorsal surface of the telson bears three very blunt carinæ, the central one broadly oval and larger than the rather narrowly oval lateral ones. The posterior half of the telson, beyond the carinæ, is armed with long, powerful, acute spines arranged approximately in two transverse rows, five spines in a row. The first row is placed just posterior to the carinæ, and consists of a long median spine immediately below the base of the median carinæ, a long intermediate spine immediately behind the lateral carina on each side, and a rather short lateral spine. The second row, which is posterior to the first, consists of five long spines, the median one immediately below that of the first row, the intermediate and lateral ones alternating with those of the first row. There is a moderately long spine on each side of the posterior end of the median carina, and two small median spines. Each lateral carina bears two small spinules at its posterior end and immediately external to the posterior end of these lateral carinæ is a small spine.

The basal joint of the *uropods* (fig. 15) bears a strong posterior dorsal tooth. The paddle of the endopodite has its inner margin drawn out into six acute spines, its outer margin as usual fringed with setæ. The external margin of the basal joint of the exopodite bears eight strong spines. The terminal joint or paddle is small, its inner margin drawn out into three acute spines, its outer margin setose.

The *raptorial claw* (fig. 12) is of the usual type, without a notch on the external margin of the dactylus, and the internal margin of the propodus minutely serrated.

A figure of the endopodite of the first abdominal appendage of the male (fig. 13) is given for comparison with other species.

Length of the type male 8 millims., of the type female 10 millims.

The *colour* of the preserved specimens is uniformly pale, with rather a characteristic group of chromatophores on the first abdominal segment, and a less distinct group on the ante-penultimate thoracic segment.

This species of *Gonodactylus* is abundantly distinguished from all known species of the genus by the spinous inner margin of both paddles of the uropods, as well as by the rather distinctive armature of the telson.

Odontodactylus brevirostris (Miers, 1884).—Plate II., figs. 16 to 18.

Locality :—Pearl Banks, Gulf of Manaar. One female, 16 millims.

I have thought it advisable to give a brief description of the single Ceylon example.

The *rostrum* (fig. 16) is rather more than twice as wide as long, quite smooth, not sinuate but transverse, and evenly rounded in outline. The centre of the anterior margin is, however, slightly depressed, so that the rostrum, *in situ*, appears to be slightly emarginate (fig. 17).

The *carapace* is rectangular in outline, of about equal width throughout and having its antero-lateral and postero-lateral angles rounded.

The lateral parts of the last three thoracic segments are rounded.

The *abdomen* is of about equal width throughout. The postero-lateral angles of the first three segments are rounded, those of the fourth and fifth produced into short acute spines. The first five segments are quite smooth and devoid of all carinæ and ridges. The sixth segment bears six rather sharp carinæ, all of which end posteriorly in acute spines. There is also a small tubercle on each side of the sixth segment between the intermediate and lateral carinæ.

There is no spine at the articulation of the uropods.

The *telson* has the six marginal spines well developed, long and acute, the submedian ones with a movable spinule at their tips. There are sixteen submedian two intermediate, and a single lateral denticle on each side. The dorsal surface bears a median crest and four other rather sharp carinæ. The dorsal crest is interrupted slightly at its anterior end, and posteriorly it ends in a prominent spine. The carina on each side of the crest is very low and does not end posteriorly in a spine. The lateral carinæ are more elevated than the intermediate ones and not spinous posteriorly. There is also a prominent carina running into the submedian spines.

The *uropods* have the outer spine of the basal prolongation longer than the inner and reaching to the level of the tips of the submedian spines of the telson. The basal joint of the exopod bears ten strong movable spines on its outer edge.

The *raptorial claw* (fig. 18) has the dactylus very little ventricose at its base and provided with seven spines on its internal margin in addition to the terminal one.

Length 16 millims.

The *colour* of the specimen, as preserved, was dark mottled brown with traces of purple on the uropods. The second to the sixth abdominal segments have four small equidistant dark eye-spots.

The above specimen differs from the type in having only seven teeth instead of eight on the internal margin of the dactylus of the raptorial claw, but its close agreement with it in other characters leaves little doubt that it belongs to the same species.

O. brevirostris appears to be very closely allied to *O. havanensis*, BIGELOW, 1894. The latter has the rostrum more semicircular than *O. brevirostris*, and the dactylus of the raptorial claw is more dilated at the base and bears only six teeth on its internal margin.

The type, and only previously known specimen, of *O. brevirostris*, was taken in 19 fathoms off Providence Island, Indian Ocean. It is thus an addition to the Stomatopod fauna of Ceylon.

Protosquilla trispinosa (DANA), var. *pulchella*, MIERS (1880).

Localities :—

Pearl Banks, Gulf of Manaar, February, 1902, 6 to 11 fathoms. Two females, 44 and 15 millims.

South-west of Palk Bay, off Adam's Bridge and Rámésw aram Island, 7 to 9 fathoms. One female, 38 millims.

Coral Reefs, Gulf of Manaar. One female, 17 millims.

This variety differs from the type species mainly in the absence of corrugations on the median portion of the fifth abdominal somite

An examination of WHITE'S type of *Protosquilla trispinosa* reveals the presence of a few scattered corrugations on the fourth segment of the abdomen. They are not present in MIERS' type of var. *pulchella*, nor in any of the Ceylon specimens.

The two large females in this collection appear to differ from the smaller ones and from MIERS' type in having the tubercles on the sixth abdominal segment much more swollen and without spines. It is possible that the spines on the tubercles are hidden by the general spinulose armature, or they may become obsolete in large examples. The small specimens had the tubercles of the telson very much less densely spinulose than the large ones.

Distribution :—*P. trispinosa*, var. *pulchella* is only known from Ceylon (MIERS) and the Indian Archipelago (DE MAN). The type form has also been recorded from Trincomalee, Ceylon, by HENDERSON, and seems to have a wide Indo-Pacific range.

Protosquilla spinosissima (PFEFFER).—Plate II., fig. 19.

Gonodactylus spinosissimus, PFEFFER, 1889.

Localities :—

Coral Reefs, Gulf of Manaar. Six females, 31, 29, 28, 28, 26 and 25 millims.; five males, 23, 23, 22, 21 and 20 millims.

Muttuvaratu Paar, 45 to 50 fathoms, from the cavities of Coral. Eight females, 28, 27, 27, 25, 24, 24, 23 and 19 millims.; eight males, 27, 25, 23, 21, 21, 21, 20 and 13 millims.

Pearl Banks, Cheval Paar. One male, 24 millims.

Talaivillu Paar. One male, 10 millims.

Through the kindness of Professor PFEFFER I have been permitted to examine the type of this species, with which I find the Ceylon specimens in perfect agreement. LENZ (1905) has recently pointed out that this species is a true *Protosquilla*, combining, as it does, a tridentate rostrum with the complete fusion of the sixth abdominal segment with the telson. It has thus no connection with *Gonodactylus spinosus*, with which BIGELOW, when describing the latter, compared it. A brief description of the species is appended, and a figure of the endopodite of the first abdominal appendage of the male given for comparison with that of other species (fig. 19).

The *rostrum* has the median spine very long and acute, extending to the corneal part of the eye. The lateral spines are acute, but not as much produced as the median one, and extend along the outer edge of the eye not quite as far as the corneal part.

The *carapace* is of about equal width throughout and oblong in shape. The antero-lateral angles are acutely rounded, while the postero-lateral angles are more broadly rounded.

The lateral parts of the last three thoracic segments are rounded.

The *abdomen* increases in width slightly from the front backwards. The postero-lateral angles of the first three segments are rounded, while those of the fourth and fifth segments are acutely produced. The first four segments have well-marked marginal carinæ, but are otherwise quite smooth. On the lateral parts of the fifth segment there are two or three sharp carinæ separated by slight furrows. The central part is almost smooth, except near the posterior margin, where a few short, scattered, transverse furrows may be noticed. The sixth segment is fused completely with the telson, though the suture is still distinctly visible. On its dorsal surface there are four rounded tubercles, the median two of which are smaller than the lateral ones, placed near to one another and separated from the lateral tubercles by a furrow. The tubercles and lateral parts of the segment are thickly beset with numerous, long, acute, upright spines.

The *telson* is longer than broad, with its lateral edges slightly curved. The posterior margin is cleft in the centre by a triangular fissure into two somewhat diverging lappets. Each of the latter is again divided by a very much shorter slit into two spines, which correspond with the submedian and lateral spines of the telson, the intermediates being suppressed. The dorsal surface bears three very prominent rounded tubercles, the median one placed anterior to the cleft, the lateral ones being placed entirely posterior to the median, one on each apical lappet. The median

tubercle is bounded laterally and posteriorly by a deep furrow. The whole surface of the telson is thickly beset with spines similar to those on the sixth abdominal segment. The spines on the lateral portions of the telson external to the tubercles are arranged in three rows.

The *uropods* have the outer spine of the basal prolongation much broader and longer than the inner, and reaching to the top of the telson. The basal joint of the exopodite bears nine or ten stout spines on its outer edge. Its paddle is rather small.

Length of the largest male 27 millims., of the largest female 31 millims.

The *colour* of preserved specimens is generally dark, with various mottlings, the tubercles of the sixth abdominal segment and the telson tinged distinctly red.

This *Protosquilla* approaches most nearly to *P. brooksii*, DE MAN, and *P. hystrix*, NOBILI. The former may be distinguished from *P. spinosissima* (1) by having the four tubercles on the sixth abdominal segment quite smooth; (2) by the much fewer and much shorter spines on the telson and the sixth abdominal segment; (3) by the cleft in the lateral apical portions of the telson being nearly obsolete.

P. hystrix differs from the present species (1) in the absence of tubercles from the sixth abdominal segment; (2) in the form of the spines arming the sixth abdominal segment and the telson, which are shorter and stouter than in *P. spinosissima*, and hooked at the tip instead of simple.

Distribution:—The type and only previously known specimen of *P. spinosissima* was taken at Zanzibar, West Coast of Africa. The species would appear to be by no means rare in Ceylon.

STOMATOPOD LARVÆ.

BELONGING TO THE GENUS **Squilla**, FABRICIUS.

Alima *α*.—Plate II., figs. 20 to 25.

Localities:—

South end of Red Sea, surface tow-net. Thirteen, 11 to 23 millims.

Off Ráméswaram Island, surface tow-net. Seven, 4·5 to 7 millims.

Palk Bay, trawl. Eighteen, 12 to 27 millims.

Off Mutwal Island, surface tow-net. One, 27 millims.

All the above *Alimæ* appear to belong to one species. It will be most convenient to describe the largest specimen first, and then add a note on the small specimens.

Larva 27 millims.

Body generally greatly elongate and narrow; *rostrum* fairly short, about one-third of the length from the antero-laterals to the posterior margin of the carapace; *antero-laterals* short, not extending to the eye-stalk; *postero-laterals* rather long, reaching to the junction of the second and third abdominal segment, a single secondary spine near to its base; *postero-median dorsal spine* short; about sixteen small denticles on the lower (ventral) in-turned edge of the carapace; the latter with

a very well-marked carina running down the whole of its median dorsal length and terminating in the postero-dorsal spine. Last three thoracic segments exposed behind the carapace; all the abdominal segments with their postero-lateral angles very acutely drawn out into spinous processes; sixth abdominal segment with a pair of median dorsal spines on its posterior border.

Telson (fig. 23) quite flat, without carinæ of any sort, but a series of well-marked concentric pits present, about one and a fifth times longer than broad, six marginal spines, well developed, acute, and slightly curved; margin between the submedian spines deeply emarginate, with a slight notch in the centre, and bearing seventeen denticles on each side; eleven intermediate and a single lateral denticle present on each side.

Uropods (fig. 24) barely reaching the level of the lateral spines of the telson; traces of six spines on the external edge of the outer branch; inner spine of the basal prolongation slightly longer than the outer, but not yet reaching the tip of the outer uropod.

Eyes somewhat large, placed on slender stalks.

Raptorial claw (fig. 25) with no signs of teeth as yet on the dactylus, two prominent teeth at the proximal end of the propodus, the inner margin of which is spinulose.

Last three thoracic appendages present and biramous, but still very small.

Abdominal appendages well developed, with gills just showing.

The smallest larva belonging to this species in the collection measures 4·5 millims. in length (fig. 20). It has the carapace rather wider, proportionally, than older larvæ, but the median dorsal carina is already very well marked. There are three spines on the ventro-lateral edge of the carapace between the antero- and postero-lateral spines, and a single secondary spine on the latter. The telson (fig. 21) is of somewhat different shape to the older larvæ, being much more quadrangular, with the marginal spines much shorter. The margin between the submedian spines is relatively much wider and more shallowly emarginate, without a trace of median notch. The telson bears seven submedian, five intermediate, and a single lateral denticle on each side.

The next stage, 7 millims. long, has a carapace much as in the last. The telson, however, has assumed a much more octagonal shape (fig. 22), and the margin between the submedian spines is relatively much narrower and more deeply emarginate than in the larva of 4·5 millims. The marginal spines are much more prominent, and there are fourteen submedian, ten intermediate, and a single lateral denticle on each side.

After 7 millims. the larva assumes practically the same shape as described above for a 27 millims. larva, and a slight notch appears in the margin of the telson between the submedian spines. The marginal spines likewise become longer and more acute.

This *Alima* is most closely allied to *Alima bidens*, Claus. The latter is the only *Alima*, as far as I am aware, which has a well-marked median carina on the carapace,

but the present *Alima* differs from *A. bidens* in having a well-marked postero-median dorsal spine on the carapace.

Three *Alimæ*, captured in a trawl off Galle, do not seem to differ materially from the above except in size. They measure 19 millims. in length, but are more advanced in their development than the larva of 27 millims. described above. The uropods extend very nearly to the intermediate spines of the telson and have traces of seven spines on the outer edge of the external branch. The telson is about as long as broad, and bears twelve submedian, ten intermediate, and a single lateral denticle on its margins. Its shape is in substantial agreement with the 27-millims. larva described above.

Alimerichthus unidens, LANCHESTER, 1902.—Plate II., fig. 26.

Locality:—East of the Gallehogalle Bank, 16 to 30 fathoms, fine sand. Two specimens, 12 millims. and 9 millims. long, from the eye to the telson.

The largest of the Ceylon larvæ is practically the same size as LANCHESTER'S type, and appears to be at the same stage of development. I am able to confirm the fact, established by LANCHESTER, that in some *Alimerichthii* at least the postero-lateral angles of the abdominal segments end in acute spines, because both in the specimens here referred to *A. unidens*, and also in another species described below, such spines are distinctly present and well developed. As points not noticed by LANCHESTER, it may be mentioned that the telson in both specimens has forty-four submedian spinules and eight intermediate ones. There are eight spines on the outer uropod of the large specimen, but only two on that of the smaller, a difference quite in accordance with the difference in size. The dactylus of the raptorial claw (fig. 26) has in both specimens one fully developed spine in addition to the terminal one and traces of two others beneath the skin. A figure of the raptorial claw is given for comparison with the other *Alimerichthus* described below.

Distribution:—Maldive and Laccadive Islands (LANCHESTER). This is the only previous record for the species, the distribution of which is now extended to Ceylon.

Alimerichthus α.—Plate II., figs. 27 to 29.

Locality:—Cheval Paar, 7 fathoms. Two specimens, 9 millims. and 10 millims. long from eye to telson.

This larva differs chiefly from *A. pyramidalis*, LANCHESTER, and *A. unidens*, LANCHESTER, the only two described species of this type of larva, in size, being only 9 millims. long, but at a stage in its development rather later than either *A. pyramidalis* at 16 millims. or *A. unidens* at 12 millims. It evidently belongs to a smaller species of adult than either of the above two. A brief description may enable the species to be recognised in any future collections.

Carapace (figs. 27 and 28) rather wide, leaving only one thoracic segment exposed, exhibiting in lateral view the same pyramidal form already noticed by LANCHESTER

for the other species of the type; rostrum slightly shorter than the length of the carapace extending to about the same level as the flagella of the antennules, two ventral spinules at about the level of the eye; posterior median dorsal spine well developed, arising from the pyramidal base noted above, much shorter than the postero-lateral spines, a prominent carina running from the rostrum along the middle of the carapace, terminating in the postero-dorsal median spine; antero-lateral spines rather short, with a prominent spine of equal length arising from their bases and projecting ventrally; postero-lateral spines well developed, extending backward to the level of the boundary between the second and third segment of the abdomen, with a secondary spinule on each near the base; no prominent ventro-lateral spine on the carapace midway between the antero- and postero-lateral spines, as seen in *A. pyramidalis* and *A. unidens*; two small spinules on the ventro-lateral margin very near to the point of origin of the postero-lateral spines.

Abdomen with all its segments well developed, each having their postero-lateral corners very acutely drawn out into spines, rather more so than in *A. unidens;* sixth segment with a pair of rather long and acute spines on the median posterior border.

Telson about as long as broad, six marginal spines well developed and acute; between the submedian spines there are 32 denticles, that is, 16 on each side of the centre; between the submedian and intermediate spines on each side there are 7 intermediate denticles, and between the intermediate and lateral spines on each side there is a single lateral denticle situated at the base of the lateral spine.

Appendages of abdomen all well developed, each with a rudiment of the future gills already present.

Uropods fairly well developed, reaching slightly beyond the lateral spines of the telson; basal prolongation with the inner spine much longer than the outer, and exhibiting a very slight swelling near the origin of the latter; external edge of the outer branch showing traces of six spines.

Raptorial claws (fig. 29) having the dactylus with two developed spines in addition to the terminal one, and showing traces of two more below the integument.

Length 9 millims.

The second specimen, which measures 10 millims., agrees perfectly with the above description except that the telson only has 26 denticles between the submedian spines and six denticles between the submedian and intermediate spines on each side. The distinguishing features of this larva are :—

(1) Its small size taken with its advanced state of development;
(2) Absence of a prominent ventro-lateral spine on the carapace;
(3) The spines arming the dactylus of the raptorial claw;
(4) The spinulation of the telson.

This *Alimerichthus* at 9 millims. long is at exactly the same stage of development as CLAUS' *Alimerichthus* at 18 millims. long (CLAUS, 1871, fig. 30).

BELONGING TO THE GENUS **Lysiosquilla**, DANA.

Lysioerichthus duvaucellii (GUÉRIN).

Locality :—East of Gallehogalle Bank, 16 to 30 fathoms, fine sand. One specimen, 22 millims. long, excluding rostrum.

The single example which I refer to this distinct and rather remarkable species agrees in all particulars save two with CLAUS' figures (CLAUS, 1871, fig. 16). The first point of difference lies in the complete absence from the present specimen of a dorsal spine. In CLAUS' figure the latter is represented by a slight acumination only.

The Ceylon specimen has two very small spinules between the submedian and intermediate spines of the telson and a very small one at the base of the lateral spines. These spinules are not represented in CLAUS' figures, but are so small as to be easily overlooked. The raptorial claw shows indications of seven teeth below the skin, and the outer uropod is armed with five not fully developed spines.

From a comparison of the Ceylon specimen with the figures of *L. duvaucellii* given by CLAUS (1871), BROOKS (1886), and JURICH (1904), it seems at least doubtful that all three writers were dealing with the same species.

It is unfortunate for an absolute settlement of this point that CLAUS omitted to mention the length of his specimen. The Ceylon example, which seems almost certainly to belong to the same species as CLAUS', measures 22 millims. without the rostrum, but is considerably more developed than BROOKS' largest specimen (which is stated to be over an inch, *i.e.*, 25 millims. in length), in having more segments of the abdomen exposed below the carapace, in the limbs of these segments being much more advanced in development as shown by the appearance of gills and in having more spines on the outer uropod, and differs in the absence of the dorsal spine of the carapace. JURICH's largest specimen, which measures 20·5 millims. without the rostrum, agrees with BROOKS' figures in all essential particulars, and the differences between them, namely, the less developed abdomen and the absence of indications of teeth beneath the skin of the raptorial claw in JURICH's specimen, are only those of age. From these considerations it seems improbable that BROOKS' and JURICH's specimens belong to the same species as CLAUS', though certainly very nearly allied. BROOKS mentions that some of his larvæ were without the dorsal spine on the carapace, but, if this latter gradually becomes obsolete as larval development proceeds, we should naturally expect that it would be his largest larvæ which would be without the spine. This is not so, as is apparent from the text. It is more probable that he had two species of larvæ under consideration. As already noted, a definite conclusion on this point is precluded by a want of knowledge of the size of CLAUS' larva, but the possibility of two closely allied species of larvæ having been confounded under the one specific denomination, *L. duvaucellii*, seems worthy of notice.

Distribution :—Bay of Bengal (GUÉRIN); Indian Ocean (CLAUS); West Pacific ("Challenger"); Indian North Equatorial Current (JURICH).

Lysioerichthus *α*.—Plate II., figs. 30 to 34.

Localities :—

Off Kalpentyn Island, surface tow-net, all night. One, 8 millims.

Cheval Paar, surface tow-net. One, 8 millims.

Off Mutwal Island, surface tow-net. One, 7 millims.

This species is very closely allied to *L. ophthalmicus*, Hansen, from which it chiefly differs in having a pair of spines on the postero-median border of the sixth abdominal segment.

Carapace (fig. 30) rather small and compact; rostrum short, about one-half of the total length of the carapace, no ventral teeth; antero-lateral spines very small indeed; postero-lateral spines rather short, not reaching to the posterior end of the first abdominal segment, without secondary spinules; postero-median dorsal spine and lateral spinules of any kind absent.

Abdomen with all the segments developed, and having their postero-lateral corners acutely angulated; pleopods all well developed, but no rudiments of gills present; sixth abdominal segment with a pair of median dorsal spines on its posterior border.

Telson about as long as broad, six marginal spines present; margin between the submedian spines almost straight, without trace of median cleft, and bearing twenty-four submedian denticles; one intermediate denticle present between the submedian and intermediate spines of each side; no lateral denticles.

Uropods (fig. 31) fairly well developed, extending as far as the level of the lateral spines of the telson; traces of four spines on the external margin of the outer branch; outer spine of the basal prolongation very much longer than the inner one.

Second to fourth thoracic appendages (figs. 32 to 34) agree in essential details with those figured by Hansen for *L. ophthalmicus*.

Last three thoracic appendages, though still very imperfectly developed, are, however, already biramous.

Length 8 millims.

The specimen, 7 millims. long, agrees well with the above description, but is generally less developed, having only three spines on the outer uropods, and the last three thoracic appendages are mere buds. It has also only twenty-two submedian denticles on the telson.

Among all described *Lysioerichthii* the present species comes nearest to *L. ophthalmicus*, Hansen (1895), from which it differs (1) in having a pair of submedian spines on the posterior border of the sixth abdominal segment, and (2) in the relatively smaller size of the inner spine of the basal prolongation of the uropods.

Lysioerichthus *β*.—Plate III., figs. 35 to 40.

Localities :—Muttuvaratu Paar, surface tow-net. Two hundred and seventy-five specimens, from 2 millims. to 6 millims. in length.

South end of Cheval Paar, surface tow-net. One specimen. 5 millims.

East Cheval Paar, surface tow-net. Two specimens. 5·5 millims. and 7 millims.

South end of Mutwal Island, surface tow-net. Seven specimens, 6·5 millims. to 8·5 millims.

North end of Chilaw Paar, surface tow-net. Three specimens, 4 millims.

Description of largest specimen:—

The length of the largest specimen of this larva was 8·5 millims. from the eye to the telson, or 11 millims. from the tip of the rostrum to the telson.

Carapace with the rostrum very long and acute, its length measured from the antero-lateral spine to its tip greater than the length from the antero-lateral spines to the posterior border of the carapace; six small spinules on the ventral edge of the rostrum; antero-lateral spines quite small; postero-lateral spines long, extending half-way along the telson, with a prominent spine at its base projecting ventrally; postero-median dorsal spine quite short; dimensions of carapace, length from antero-laterals to the posterior border, 3·5 millims.; antero-laterals to tip of rostrum, 4 millims.; postero-lateral spines, 3 millims.

Abdomen, with all the segments and their appendages developed; first segment hidden by the carapace; postero-lateral angles of all the segments rounded; sixth segment without a pair of median dorsal spines; appendages all well developed, and setose, with the gills just appearing.

Telson (fig. 41) about one-third as broad again as long; six marginal spines well developed; the margin between the submedians with two very prominent spines dividing this part of the margin of the telson into three parts, each part deeply emarginate, the central part slightly smaller than the lateral portions and each portion bearing seven spinules with very minute comb-like spinules in between; two intermediate and one lateral spinule present on each side.

Uropods short, only as yet reaching to the lateral spines of the telson; outer edge of external branch with two spines; ventral prolongation of the uropods with the two spines subequal in length.

Raptorial claw (fig. 40) still without any signs of teeth below the integument; last three thoracic appendages present and biramous, but very small.

The large number of larvæ of this type present in the collection has enabled me to trace, in a fairly complete manner, its life-history from the earliest stage, the *Erichthoidina*, to the stage described above. The most important and interesting changes are undergone by the carapace, and a study of these changes has led me to differ from Brooks in one or two points. A very brief description of larvæ at various stages may first, with convenience, be given.

Larva 2 millims. (tip of rostrum to telson). This is the smallest larva of the series, and represents the *Erichthoidina* stage. The carapace is without any trace of antero-laterals and there is no spine at the base of the postero-laterals. The rostrum is quite short and without ventral spinules. The postero-laterals are also very

short (fig. 35). A larva of 3 millims. is in substantial agreement with the one at 2 millims. except that the rostrum is relatively a little longer.

Larva 4 millims. This stage (fig. 36) is distinguished by the appearance of a small spine at the base of the postero-lateral spines of the carapace. The rostrum is relatively longer than in the 3-millims. stage, and now bears a single ventral spinule. A single thoracic segment is exposed posterior to the carapace.

Larva 5 millims. This larva agrees very well with the one at 4 millims., but the rostrum is a little longer and bears two ventral teeth (fig. 37). Two thoracic segments are now exposed behind the carapace.

Larva 6 millims.—At this stage the antero-lateral spines of the carapace make their first appearance. The rostrum continues to increase proportionally in size and now bears four ventral spinules. The postero-lateral spines are likewise relatively longer and the uropods are just discernible as buds.

Larva 7 millims.—The carapace (fig. 38) is now fully formed with antero-laterals, postero-laterals, and the spine at the base of the latter, all well developed. The rostrum is as long as the remainder of the carapace from the antero-laterals to the postero-median dorsal spine, and bears fine ventral spinules. The uropods show one spine on the outer edge of the external ramus.

Later stages only differ from the 7-millim. larva in the continued relative increase in length of the rostrum and postero-lateral spines, to the proportions shown in the larva 9 millims. (fig. 39), which agrees with the still larger larva, 11 millims. long, described above.

During development the telson gradually becomes broader in proportion to its length (see figs. 36, 39 and 41), but the number of spines varies very little from the numbers given in the description of the large larva above.

A comparison of the figures here given to illustrate this *Lysioerichthus* larva with figs. 1, 2A, 2B, 4 and 5 of CLAUS' memoir (1871) will show that the species dealt with here is very closely allied to, if not identical with, the one CLAUS had under observation, and that the three supposed species of *Erichthoidina* described by the latter author under the names *E. gracilis*, *E. armata* and *E. brevispinosa* in all probability represent developmental stages in the life-history of one species only, the development of which, as gleaned from CLAUS' figures, follows very closely the lines indicated in the Ceylon larvæ. The latter are also in all probability identical with the *Erichthoidina* figured by BROOKS in his "Challenger" Monograph, plate xii., figs. 1 and 2. BROOKS has expressed the opinion that CLAUS' *E. brevispinosa* is a young stage of *Gonodactylus*, and bases his view on the presence in the latter of a spine at the base of the postero-lateral spine of the carapace which he regards as characteristic of *Gonerichthii*. The Ceylon series clearly shows that this spine, though not present in the earliest *Erichthoidina*, is a later development, and thus its presence cannot be regarded as diagnostic of *Gonerichthii*, but may be present in some *Lysioerichthii* as well (see also HANSEN, 1895, plate vii., figs. 4A and 5A, where such

a spine is represented on the carapace of two species of *Lysioerichthii*). For this reason I venture to differ from Brooks, in regarding Claus' *Erichthoidina brevispinosa* as a *Lysioerichthus* rather than as a *Gonerichthus*.

Belonging to the genus **Pseudosquilla** (Guérin) Dana.

Pseuderichthus communis, Hansen (1895).

Locality :—South end of the Red Sea, surface tow-net. One specimen, 15 millims.

Herdman's example is smaller than either Claus', Hansen's or Jurich's larvæ, but agrees well with all three in its chief points. At this stage, however, only three spines are to be noted on the outer uropod. The tooth on the ventral edge of the rostrum just in front of the eye is very prominent.

Distribution :—General throughout the tropical Atlantic and Indian Oceans (Claus, Hansen and Jurich).

Belonging to the genus **Gonodactylus**, Latreille.

Gonerichthus *α*.—Plate III., fig. 42.

Locality :—Cheval Paar, surface tow-net. One specimen, 11 millims. long from eye to telson.

Carapace (fig. 42) with rostrum fairly long, equal in length to the rest of the carapace from the eye to posterior dorsal spine ; about eight small denticles on the ventral edge of the rostrum ; antero-lateral spines short ; postero-lateral spines long, extending to the junction of the third and fourth segments of the abdomen ; a small postero-ventral spine at the base of the postero-laterals ; postero-median dorsal spine very small.

Abdomen with all the segments developed, and having their postero-lateral corners acutely angulated ; sixth segment with a pair of small median dorsal spines on its posterior border ; appendages all well developed, biramous and setose ; gills well developed and already digitate.

Telson about as long as broad, six marginal spines well developed and somewhat acute ; margin between the submedian spines somewhat deeply emarginate and distinctly notched, bearing thirty submedian denticles ; two intermediate and a single lateral denticle present on each side.

Uropods very well developed and almost as long as the telson ; external margin of the outer branch with only two distinct spines ; inner spine of the basal prolongation much longer than the outer, which is quite small.

Raptorial claw without any signs of spines on the dactylus ; last three thoracic appendages well developed and biramous.

Length 11 millims. from the eye to the telson.

This larva is distinguished among *Gonerichthii* by the somewhat unusual character of having the inner spine of the basal prolongation of the uropod much longer than the outer. In no *Gonerichthus* yet described is such a character found. In other respects the larva is a perfectly typical *Gonerichthus*, especially in the characters of the third and fourth thoracic limbs, which have not the swollen propodus characteristic of *Lysioerichthii*. The larva is very far advanced in development, but the raptorial claw shows no signs of spines on the dactylus. It must be concluded therefore that the larva belongs to the genus *Gonodactylus*.

Gonerichthus β.—Plate III, figs. 43 to 45.

Locality :—Off Kalpentyn Island, surface tow-net, all night. Forty-two specimens, from 4 to 7 millims. in length from eye to telson.

Carapace (figs. 44 and 45) with rostrum very long, the length from the antero-lateral spines to the tip of the rostrum exceeding the length from the antero-laterals to the posterior median dorsal spine ; eight small teeth on the ventral edge of the rostrum ; antero-lateral spines very small ; postero-lateral spines very long, extending to the junction of the sixth abdominal segment with the telson, a small spine at its base projecting ventrally ; postero-median dorsal spine very short.

Abdomen with all the segments well developed, and having their postero-lateral angles slightly angulated ; sixth segment with a pair of median dorsal spines on its posterior border ; abdominal appendages very well developed, with digitate gills already present.

Telson rather longer than broad ; six marginal spines present ; margin between the submedian spines emarginate, with a slight notch in the centre, and bearing twenty-four submedian denticles ; two intermediate denticles present on each side, but no lateral denticle could be discerned.

Uropods well developed, extending to the level of the intermediate spines of the telson ; traces of ten spines on the external margin of the outer branch ; outer spine of the basal prolongation extending nearly to the level of the submedian spines of the telson, much longer than the inner spine.

Raptorial claw without traces of spines on the dactylus ; third and fourth thoracic appendages of the usual *Gonerichthus* type, and not exhibiting the swollen propodus of the *Lysioerichthus* ; last three thoracic appendages fairly well advanced and already biramous.

Length 7 millims. from the eye to the tip of the telson.

The smaller larvæ referable to this type differ chiefly in the proportional length of the rostrum and postero-lateral spines, both of which increase in comparative length as the larva advances (see fig. 43).

This type evidently belongs to quite a small species of adult. At 7 millims. length it is as far advanced as type α at 11 millims., and is evidently not far from maturity. It is one of the most abundant *Erichthus* larvæ in the collection.

Gonerichthus γ.—Plate III., figs. 46 to 47.

Localities :—

Off Kalpentyn Island, surface tow-nets all night. Twelve specimens, from 4 to 7 millims. in length from the eye to the telson.

Cheval Paar, surface tow-net. Three specimens, 5 to 6 millims. long.

This *Gonerichthus* is very closely allied indeed to the last, and the description there given will answer for this species, save in the following particulars :—

Rostrum (figs. 46 and 47) comparatively much shorter, the length from the antero-lateral spine to its tip being much shorter than the length from the antero-laterals to the postero-median dorsal spine ; only three or four teeth on its ventral edge.

Antero-lateral spines of the carapace, though still small, are more developed than in type β.

Postero-lateral spines relatively much shorter, and only extend about half way down the second abdominal segment.

Telson, while agreeing in general shape and armature, is comparatively a little broader.

The above comparison between the types β and γ is drawn up from specimens of the same size, 7 millims., and at the same stage of development. Figs. 46 and 47 show the carapace of the type γ in dorsal and lateral view respectively, and the differences between types β and γ are readily seen in comparison with figs. 44 and 45, in which the carapace of type β is shown. Type β at 4 millims. has a carapace of about the same proportions as type γ at 7 millims. (see fig. 43). It seems clear from this that the larvæ β and γ are distinct and belong to separate though closely allied adults.

LIST OF LITERATURE.

LEPTOSTRACA.

G. O. Sars, 1887.—'Report on Phyllocarida, "Challenger,"' Zool., vol. xix.

G. O. Sars, 1890.—'Fauna Norvegiæ,' Band i., Phyllocarida and Phyllopoda.

Thiele, 1904.—"Leptostraca" in 'Wiss. Ergeb. Deutschen Tiefsee-Exped.,' Band viii., Lief. 1.

SCHIZOPODA.

Czerniavsky, 1882.—'Monograph Mysid. Ross.'

Dana, 1852.—'U.S.A. Exploring Exped.'—XIV., Crustacea.

Hansen, 1905, I.—"Prelim. Rep. Schiz., 'Princess Alice' for 1904." 'Bull. Mus. Ocean. Monaco,' No. 30.

Hansen, 1905, II.—"Further Notes on Schizopoda." 'Bull. Mus. Ocean. Monaco,' No. 42.

Kossmann, 1880.—'Zool. Ergeb. Reise d. Küst. d. Rothen Meeres,' Heft ii., Lief. i., Malacostraca. Leipzig.

Paulson, 1875.—'Crust. maris rubri,' Pars i.

G. O. Sars, 1885.—'Report Schizopoda, "Challenger,"' Zool., vol. xiii.

Stebbing, 1905.—"South African Crustacea."—Part III. 'Marine Invest. S. Africa, vol. iii.

STOMATOPODA.

Bigelow, 1893.—"Prelim. Notes Stomatopoda of 'Albatross.'" 'Johns Hopkins Univ. Circ.,' 106.

Bigelow, 1894.—"Report Stomatopoda of 'Albatross.'" 'Proc. U.S. Nat. Mus.,' vol. xvii.

Borradaile, 1898.—"On some Crustaceans from S. Pacific.—Part I. Stomatopoda." 'Proc. Zool. Soc. London.'

Borradaile, 1900.—"On the Stomatopoda and Macrura brought by Dr. Willey from the South Seas." 'Willey's Zool. Results,' part iv.

Brooks, 1886.—'Report Stomatopoda of "Challenger,"' Zool., vol. xvi.

Claus, 1871.—"Die Metamorphose der Squilliden." 'Abh. d. Gesell. Wiss. Göttingen,' xvi.

De Man, 1888.—"Ind. Arch. Decapoden und Stomatopoden." 'Arch. f. Naturgesch.,' 53. Jahr.

De Man, 1902.—"Ind. Arch. Decapoden und Stomatopoden." 'Abh. Senckenb. Ges. Frankfurt,' Band xxv.

Hansen, 1895.—'Isopoden, Cumaceen und Stomatopoden der Plankton-Expedition,' Band ii., G. c.

Heller, 1868.—'Novara Reise, Crustacea.'

Henderson, 1890.—"Crustacea" in 'Notes on the Pearl and Chank Fisheries and Marine Fauna of the Gulf of Manaar,' by E. Thurston, published from the Government Central Museum, Madras.

Henderson, 1893.—'Trans. Linn. Soc. London,' ser. ii., Zool., Part v.

Jurich, 1904.—"Stomatopoda" in 'Wiss. Ergeb. Deutschen Tiefsee-Exped.,' Band vii., Lief. 6.

Lanchester, 1902.—'Fauna and Geography Maldives and Laccadives,' vol. i., part 4, Stomatopoda.

Lenz, 1905.—"Ostafrikanische Decapoden und Stomatopoden." 'Abh. Senckenb. Ges. Frankfurt,' Band xxvii., Heft iv.

Miers, 1880.—"On the Squillidæ." 'Ann. Mag. Nat. Hist.,' ser. v., vol. v.

Miers, 1884.—"Crustacea" in 'Report Zool. Coll. H.M.S. "Alert," 1881–1882.' London.

Müller, 1887.—"Zur Crustaceenfauna von Trincomali." 'Verh. nat. Ges. zu Basel,' Theil. viii., Heft ii.

Nobili, 1899.—"Crustacei Austro-Malesi." 'Ann. Mus. Civ. Stor. Natur. Genova,' ser. 2a, vol. xx.

Pfeffer, 1889.—'Mitt. aus d. naturhist. Mus. in Hamburg,' vi., Jahr. 5.

Pocock, 1893.—"Stomatopod Crustaceans of H.M.S. 'Penguin.'" 'Ann. Mag. Nat. Hist.,' ser. 6, vol xi.

EXPLANATION OF THE PLATES.

PLATE I.

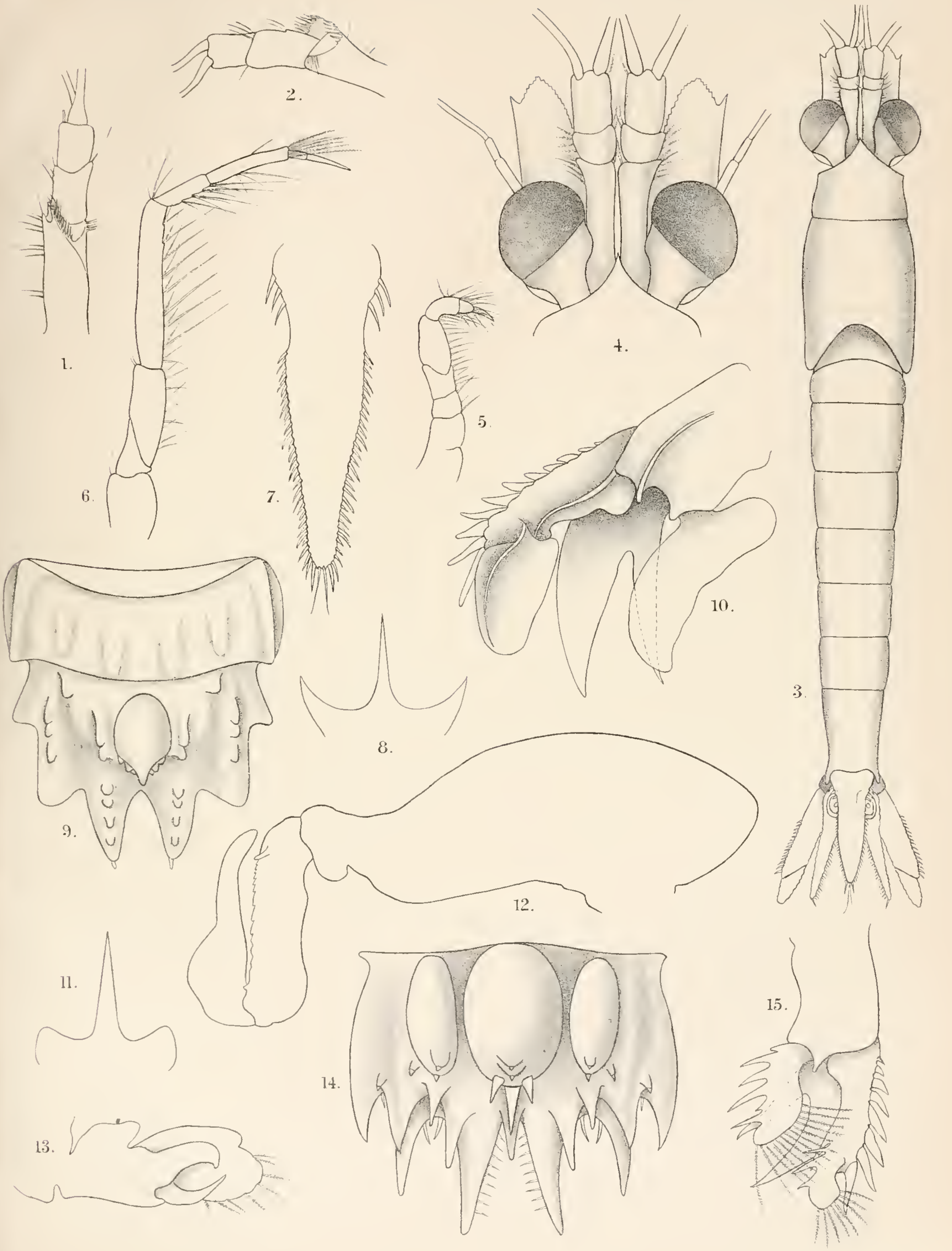
Fig. 1. *Euphausia latifrons*, G. O. SARS, left antennular peduncle, from above.
,, 2. ,, ,, ,, ,, ,, the inside.
,, 3. *Siriella paulsoni*, KOSSMANN, female, from above.
,, 4. ,, ,, anterior end, enlarged.
,, 5. ,, ,, endopodite of first thoracic limb.
,, 6. ,, ,, ,, ,, third thoracic limb.
,, 7. ,, ,, telson.
,, 8. *Gonodactylus herdmani*, n. sp., rostrum.
,, 9. ,, ,, sixth abdominal segment and telson, dorsal view.
,, 10. ,, ,, left uropod, dorsal view.
,, 11. *Gonodactylus acanthurus*, n. sp., rostrum.
,, 12. ,, ,, raptorial claw.
,, 13. ,, ,, endopodite of first abdominal appendage of the male.
,, 14. ,, ,, telson.
,, 15. ,, ,, right uropod, dorsal view.

PLATE II.

Fig. 16. *Odontodactylus brevirostris* (MIERS), rostrum, actual outline.
,, 17. ,, ,, ,, as it appears *in situ*.
,, 18. ,, ,, dactylus of raptorial claw.
,, 19. *Protosquilla spinosissima* (PFEFFER), endopodite of first abdominal appendage of the male.
,, 20. *Alima α*, dorsal view of specimen 4·5 millims.
,, 21. ,, telson of same specimen, enlarged.
,, 22. ,, ,, specimen 7 millims.
,, 23. ,, ,, ,, 27 ,,
,, 24. ,, left uropod of same specimen.
,, 25. ,, raptorial claw of same specimen.
,, 26. *Alimerichthus unidens*, LANCHESTER, raptorial claw.
,, 27. *Alimerichthus α*, dorsal view of specimen 9 millims.
,, 28. ,, side view of carapace of same specimen.
,, 29. ,, raptorial claw.
,, 30. *Lysioerichthus α*, dorsal view of specimen 8 millims.
,, 31. ,, right uropod of same specimen.
,, 32. ,, second thoracic limb of same.
,, 33. ,, third thoracic limb of same.
,, 34. ,, fourth thoracic limb of same.

PLATE III.

Fig. 35.	*Lysioerichthus* β,	lateral view of carapace of specimen 2 millims.
,, 36.	,,	dorsal view of specimen 4 millims.
,, 37.	,,	lateral view of carapace of specimen 5 millims.
,, 38.	,,	,, ,, ,, 7 ,,
,, 39.	,,	dorsal view of specimen 9 millims.
,, 40.	,,	raptorial claw of same.
,, 41.	,,	telson of specimen 11 millims.
,, 42.	*Gonerichthus* α,	dorsal view of specimen 11 millims.
,, 43.	*Gonerichthus* β,	lateral view of carapace of specimen 4 millims.
,, 44.	,,	dorsal view of specimen 7 millims.
,, 45.	,,	lateral view of carapace of same.
,, 46.	*Gonerichthus* γ,	dorsal view of carapace of specimen 7 millims.
,, 47.	,,	lateral view of same.



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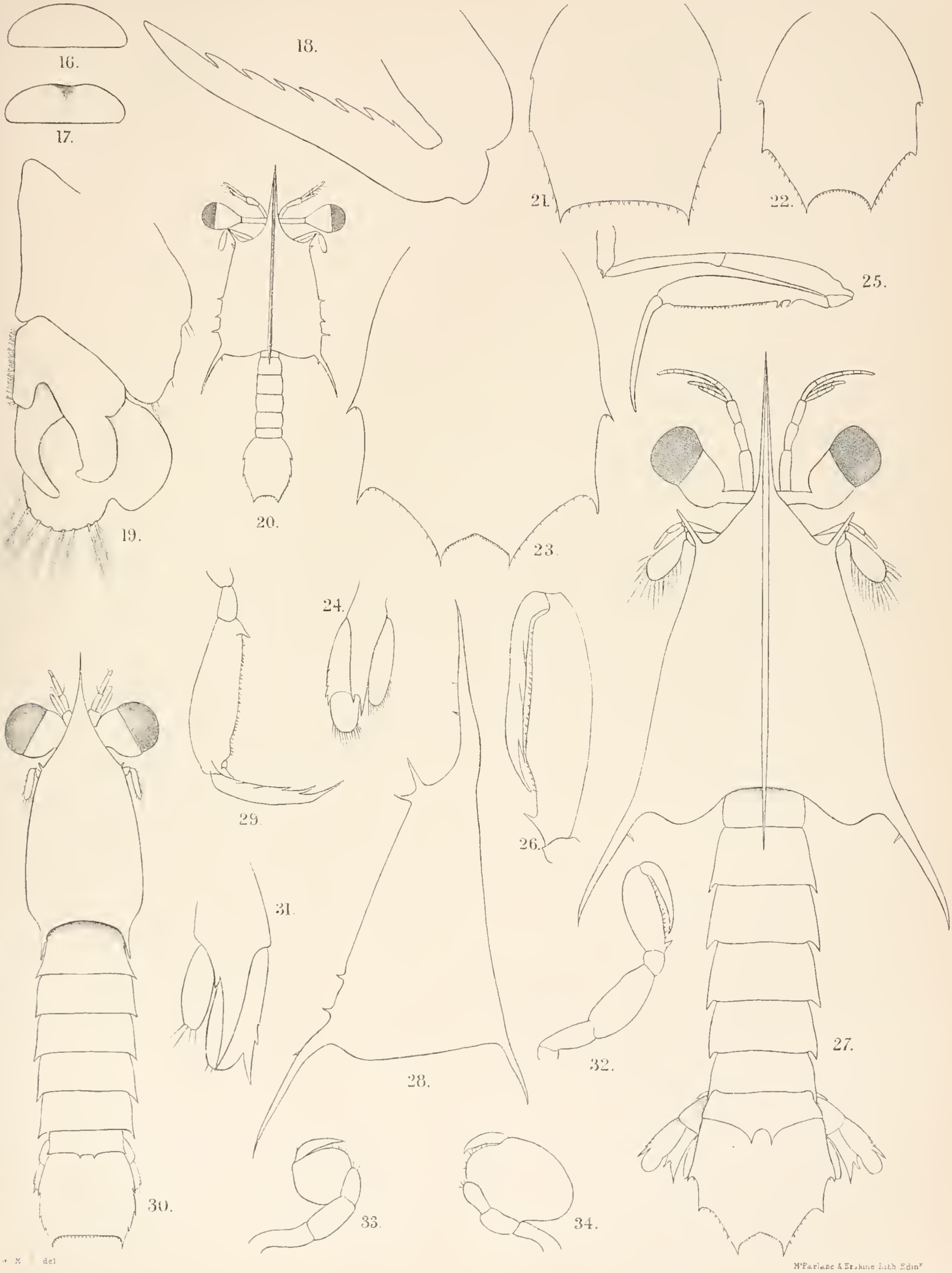
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REPORT

ON SOME

PARASITIC COPEPODA

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

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[WITH FIVE PLATES.]

OF this small collection of Parasitic Copepods* obtained by Professor HERDMAN and Mr. HORNELL at Ceylon it can be said with even greater emphasis than was declared by Rev. T. R. R. STEBBING of the Isopods from the same locality: "The interest of the present collection is not to be measured by the number of species, or the number of specimens, still less by the size of the animals."†

There were only five vials of the Parasitic Copepods, and yet from these were obtained four new species, two of which were the types of new genera. There were also two other species which had been previously described, but both of which were founded on a single sex and on a very limited number of specimens. Neither of these had been seen since originally described forty years ago. Of one of them the male sex is here added for the first time, while of the other many supplementary details of structure are given.

There was thus not a single species in the small collection which did not present something new and interesting—a truly remarkable record.

* The main report on the large collection of free and a few parasitic Copepoda, by the late Mr. I. C. THOMPSON and Mr. ANDREW SCOTT, will be found in Part I. of this work (1903) at p. 227.

† Part IV. of this Report, Supplementary Report XXIII., "On the Isopoda," 1905.

DESCRIPTION OF THE SPECIES.

FAMILY: CALIGIDÆ.

SUB-FAMILY: CALIGINÆ.

Lepeophtheirus brachyurus, HELLER—Plate I., figs. 1 to 10.

This species was briefly described by HELLER in the 'Reise der Novara,' 1865, and has not been seen by any other investigator since. HELLER'S specimens were obtained near Java upon the gills of the same host as the present Ceylon specimens.

The following description, and the figures given on Plate I., supplement as well as corroborate HELLER'S original diagnosis :—

Female.—Carapace ovate, considerably narrowed and rounded anteriorly, widened and emarginate posteriorly. The length of the carapace is more than twice that of the rest of the body, but is a little less than its width. The grooves on the dorsal surface are distinct, with the cross-bar of the H about in the centre of the carapace, while the anterior and posterior halves of the lateral grooves are inclined like the sides of an hour-glass. The frontal plates are narrow, scarcely more than one-third the width of the carapace, with a deep but narrow central incision. The eyes are moderately large and placed far forward, about one-fifth the length of the carapace from its anterior margin. The thoracic area is large and wedge-shaped, three-quarters of the width of the carapace and slightly concave at its posterior margin, less than half the width and slightly convex at the anterior margin.

The fourth or free thorax segment is very short and concealed in dorsal view by the overlapping carapace. The genital segment is transversely elliptical, one-third wider than long, with evenly rounded sides and a nearly straight posterior margin. The fifth legs are visible at the posterior corners.

The abdomen is short and narrow, one-fourth the length and one-fifth the width of the genital segment, one-jointed, with the posterior margin wedge-shaped. The anal laminæ are minute, fastened to the sides of the wedge, and each armed with three plumose setæ and a small spine.

The egg-cases are about the same length as the entire body and as wide as the abdomen. The eggs are of medium thickness, about 70 in each string.

Of the appendages, the first antennæ are short and unusually wide, a considerable portion of the basal joint being concealed beneath the edge of the carapace. The terminal joint is only about half the length of the basal and carries a tuft of spines at its tip. The second antennæ are stout and of the usual form, with a long terminal claw bent abruptly near the tip (fig. 2).

The first maxillæ are very small and rudimentary ; the basal portion is swollen and

circular, while the terminal part is slender and curved. The second maxillæ are short and simple, broadly triangular, with a narrow, pointed, and more or less curved tip. The rudimentary exopod appears as a large papilla upon the basal portion of the appendage, which is fused with the ventral surface of the carapace. These appendages are quite small, less than half the length of the mouth-tube, and are attached at some little distance to the right and left of the base of the latter. The mouth-tube itself is short and wide, somewhat triangular, with a broadly rounded tip; the mouth opening is terminal with a scanty fringe of hair (fig. 3).

First maxillipeds of the usual pattern; second pair enlarged and stout, the terminal claw strongly curved and less than half the length of the basal joint, with an accessory spine on its ventral surface near the base. Basal joint much swollen and furnished at the centre of its anterior margin with a large and stout process projecting diagonally outwards. The under surface of this process is grooved, and into this groove fits the tip of the terminal claw (fig. 4).

The furca is slender, the basal portion longer and wider than the terminal and with a large elliptical lumen, the branches slender and divergent with rounded points.

The swimming legs are of the usual pattern, but the basal joint of the second pair is very narrow. The basal apron of the third legs is also short and narrow, but it is attached so far back and the free segment is so short that it overlaps a little the genital segment. Another feature not noted by HELLER is the fact that the dorsal surface of the apron of these third legs projects backward between their rami as a rounded knob, as long as the rami themselves. These latter are small, well separated, and each is two-jointed (figs. 6 to 9).

The fourth legs are small and rudimentary, and are entirely concealed beneath the apron of the third legs, another fact not noted by HELLER. They contain only two joints of about the same length, the terminal one carrying three spines, of which the inner one is twice as long as the others.

The ovaries are rather small and triangular and are situated just behind the eyes at some distance from each other. The oviduct is coiled very regularly in the sides of the genital segment, as can be seen in fig. 10. The cement glands are comparatively wide and reach forward nearly to the anterior margin of the segment. Their anterior half is curved in toward the mid-line and is occupied by about eighteen large cells, the last two or three of which at either end diminish abruptly in size. The posterior half is even a little wider than the anterior and is filled with a homogeneous mass, in which there is no distinction of cells or ducts. The semen receptacle is bent in a half circle, the convex side forward, and is about the same diameter throughout. The vulvæ open near together on either side of the median line.

The colour of the preserved specimens is a uniform light yellowish gray, without pigment spots or lines.

Total length 4·5 millims., length of carapace 3 millims., width of same 3·35 millims.,

length of genital segment 1 millim., length of abdomen 0·5 millim., length of egg-sacs 4·4 millims.

There were two specimens of this species, both females, obtained from the gills of a puffer, *Tetrodon stellatus*. They may be easily distinguished from other species of the genus by the relatively large size of the carapace compared with the rest of the body, by the correspondingly diminutive size of the fourth segment and the abdomen, and by the rudimentary fourth legs, which are entirely concealed in both dorsal and ventral view. The large rounded spine which projects between the rami of the third legs is also peculiar to this species.

Lepeophtheirus æsopus,* n. sp.—Plate I., figs. 11 to 19.

Female.—Carapace ovate, considerably narrowed anteriorly, and a little more than two-fifths the entire length. Frontal plates prominent, but less than half the width of the carapace. Eyes large and placed well forward. Thoracic area exceptionally small, one-third the length and three-fifths the width of the carapace, its anterior and lateral margins forming nearly a perfect half circle, its posterior margin slightly re-entrant. Lateral lobes broad, blunt and short, leaving a wide sinus between the carapace and the genital segment, which is entirely filled by the large basal joints of the third and fourth pairs of swimming legs.

The fourth or free thoracic segment is transversely elliptical and widened considerably through the bases of the fourth legs. The genital segment is quadrate, two-thirds the size of the carapace, and a little wider anteriorly than posteriorly, with evenly rounded corners.

The abdomen is narrow, only one-sixth the width of the genital segment and less than half its length. It is indistinctly three-jointed, the middle joint larger than the other two, which are about the same size. The groove separating the terminal joints is distinct and can be traced the entire width of the abdomen, but the basal groove can be seen only at the margins, and it is not certain that the abdomen is really jointed there. The anal laminæ are narrow, three times as long as wide and pointed at the tips where each is armed with four small setæ. The egg-strings are wider than the abdomen and three-quarters of the entire length; the eggs are large, 50 or 60 in each string.

Of the appendages, the second antennæ have a large basal joint and a very slender terminal claw, which is bent sharply at right angles near its tip. The basal joint is re-enforced by a stout spine, pointing backward (fig. 12).

The first maxillæ are small and well curved, the basal half fused to the ventral surface of the carapace and only the tip free. As an offset to this, the second pair are exceptionally large and stout, with a broad, triangular base and a long, straight, and pointed tip which reaches far beyond the end of the mouth-tube. Each maxilla

* *Æsopus*, different footed, each pair of legs differing considerably from the ordinary type in this genus.

is two-jointed and is actually longer and wider than the mouth-tube. Upon the basal joint, which is fused to the carapace, appears the rudimentary exopod in the form of a small papilla bearing two setæ. It is situated near the centre of the basal joint and close to the endopod. The endopod itself is simple as in the genus *Caligus*, and not bifurcate as in many species of *Lepeophtheirus* (fig. 13).

The first maxillipeds are of the usual pattern, but the outer terminal claw is lengthened so that the two cross each other from opposite sides of the body when the appendages are at rest. The second maxillipeds are small and weak, the terminal claw only half the length of the basal joint, and slender (fig. 14). No trace of any furca could be found.

The first swimming legs are small and weak; the three terminal claws are of nearly the same length, as is also the seta at the inner corner. The basal joint of the second legs is exceptionally narrow, being but little wider than the connecting piece across the centre of the body; the rami are of the usual pattern. The rami of the third legs are so close together as to be in actual contact at their bases, but the exopod stands out at right angles to the basal apron, while the endopod is closely appressed to the margin of the latter. The exopod is three-jointed, the joints of about the same size; this gives it considerable length, which, together with its position, makes it unusually prominent. The basal joint also bears on its inner margin a wide circular lamina, which extends outward to the tip of the terminal joint and inward to overlap the endopod; this latter is of the usual form (figs. 15 to 18).

The fourth legs are also exceptional in having a stout and swollen basal joint and three small and weak terminal joints. The second joint also, instead of being cut off diagonally at the distal end as in other species, is cut squarely across.

The second and third joints each carry a single spine at the outer distal corner, while the last joint is terminated by a row of three spines; the five are approximately of the same size.

No fifth legs are visible, but the genital segment bears upon its margin at each posterior corner three small spines which probably represent the rudiments of these legs.

The oviducts are not much coiled in the genital segment; the cement glands are narrow and nearly straight, situated on either side of the mid-line and close to it. In the specimen observed the spermatophores were long and narrow, and turned forward along the ventral surface of the genital segment. Each was curved away from its fellow like a pair of parentheses marks; the anterior ends almost touched each other, but the posterior ends, entering the vulvæ, were about the diameter of the abdomen apart (fig. 19).

Colour of the preserved specimen a uniform yellowish white, without pigment spots or lines.

Total length 5·75 millims., length of carapace 2·4 millims., width of same

2·4 millims., length of genital segment 1·95 millims., length of abdomen 0·92 millim., length of egg-sacs 4·2 millims.

SUB-FAMILY: TREBINÆ.

Trebius exilis,* n. sp.—Plate II., figs. 20 to 33.

Female.—Carapace ovate, one-seventh longer than wide, contracted anteriorly, and well arched. Transverse grooves separating the cephalic and thoracic portions of the lateral areas situated far forward, leaving the thoracic portion much the longer of the two. Eyes small, purplish red, and some little distance from the anterior margin. Frontal plates better developed than either *T. caudatus* or *T. tenuifurcatus*, but still less than half the width of the carapace.

Third thorax segment only a trifle wider than the fourth and considerably shorter. It projects backward, however, nearly its whole length beyond the lateral lobes of the carapace, just as the thoracic area does in some of the Caliginæ (*Caligus rapax*, *C. rufimaculatus*, &c.). Fourth segment considerably longer than the third, and widened through the bases of the fourth legs more than in either of the other two species, giving it a spindle shape.

Genital segment almost a perfect ellipse, the only deviation being anteriorly, where it is contracted into a short and narrow neck before joining the fourth segment. It is more than three-fifths the size of the carapace and shows no spines or processes at the posterior corners. The egg-strings are about the same width as the abdomen, but are from two and a half to three times its length, thus contrasting sharply with those of *T. caudatus* which are but a trifle longer than the abdomen. The eggs are of medium thickness, 40 to 50 in each string.

The abdomen, even including the anal laminæ, is one-half shorter than the genital segment instead of one-half longer as in *T. caudatus*. It is also made up of a single joint and is of the same diameter throughout. The anal laminæ are elongate, more than twice as long as wide, well separated at the base, but convergent toward the tips, where each carries four good-sized plumose setæ. As in *T. caudatus*, the outer seta is the shortest, the inner one next in length, while the two middle ones are considerably longer.

Of the appendages the first antennæ are relatively much longer than in *T. caudatus*, the basal joint is stouter and more heavily armed with plumose setæ, while the terminal joint is slender, not enlarged at the tip, and stands out prominently. The second antennæ are large and stout; the terminal claw is wider at the base than in *T. caudatus* and is relatively as long. But the abrupt bend is at the centre instead of near the tip, and this makes the claw appear shorter. There is also a long and slender hair on the inner margin of the claw near its base (fig. 22).

* *Exilis*, slender, beautiful.

The first maxillæ are straight, small, and weak, and they are fused to the ventral surface of the carapace throughout their entire length, not even the tips being free.

The second maxillæ are also very different from those of *T. caudatus*. They are two-jointed, the basal joint being fused to the ventral surface of the carapace, and carrying at its centre the rudimentary exopod. This is in the form of a good-sized papilla armed with two setæ of about the same length, and less than one-third the length of the endopod. The latter is elongate-triangular, extends for half its length beyond the tip of the mouth-tube, and is bluntly pointed at the end, without any trace of bifurcation.

The mouth-tube is not as long as in *T. caudatus*, but is jointed similarly at the centre of the upper lip, with deep lateral incisions. The bony framework shows some similarity to that of both *Lepeophtheirus hippoglossi* and *Caligus rapax*. There are in it two sets of rods hinged together at the centre just above the joint (fig. 23). In the basal half the rods are four in number arranged in the form of the letter M. The two outside ones (*a*) start from just behind the bases of the mandibles and run diagonally forward and inward until they nearly meet at the mid-line. These must be regarded as belonging to the framework of the lower lip, although they are buried in the tissues of the ventral surface of the carapace. From their inner ends two other rods (*b*) start and run parallel with each other on either side of the mid-line outward nearly to the jointing at the centre of the mouth-tube. These evidently belong to the framework of the upper lip. From the outer ends of the first pair, just behind the bases of the mandibles, a stout rod (*c*) runs along either side of the under lip, the two curving around and meeting on the mid-line at the tip of the lip. Near the joint in the mouth-tube each of these rods divides and sends a branch rod up to the upper lip, the branch ending in the lateral incision on either side. Articulating with the end of the branch at this incision is a long bone (*d*), shaped like the human femur, which sweeps inwards and forwards until it meets its fellow from the opposite side near the centre of the tip of the upper lip.

The upper lip is thus jointed near its centre, while the lower lip articulates directly with the ventral surface of the carapace. As the mouth-tube naturally points backward the upper lip is longer than the lower lip, and this jointing at its centre greatly facilitates the freedom of motion. The mouth-opening is a terminal transverse slit, heavily fringed with hairs. The mandibles are slightly curved towards their tips, where they are toothed on the inner margin. They pass out through the sides of the mouth-tube at the lateral incisions and articulate with the ventral surface of the carapace just in front of the bony framework.

The first maxillipeds are comparatively large and stout as in *T. caudatus*, but the basal joint is not as much enlarged, being a trifle smaller than that of the second pair. The two terminal claws are about the same diameter, but the inner one is almost twice the length of the outer. The second maxillipeds are much reduced in size as compared with those in the Caliginæ; the basal joint is stouter than in

T. caudatus, but the terminal claw is as short and weak as in the latter species. No spine could be seen on its inner margin in any of the specimens examined (fig. 25).

The furca is small, the length four times the width, the branches short, simple, divergent, and pointed, leaving a V-shaped sinus, only one-fourth or one-fifth the entire length.

The first swimming legs have a broad and well-rounded basal joint, carrying a small seta on its posterior margin. Both rami are two-jointed, the exopod nearly twice the length of the endopod. The basal joint of the exopod is considerably wider than the terminal, and somewhat swollen; the terminal joint is only half the length of the basal, is not bent at a right angle as in *T. caudatus*, and is armed with three short and stout spines on its distal end, and three plumose setæ, as long as the entire ramus, on its posterior margin. The basal joint of the endopod is also twice the length of the terminal, and somewhat swollen; the terminal joint is bent at a right angle and tipped with three stout plumose setæ.

Second swimming legs similar to those of *Lepeophtheirus* in the shape and arrangement of the joints and in the number and distribution of the spines and setæ.

The third swimming legs are like the second, but differ in a few particulars. The exopod carries three spines on the outer margin of the terminal joint; the basal and second joints of the endopod are much enlarged, while the terminal joint is reduced in size and carries only four plumose setæ.

The fourth swimming legs are very different from those of *T. caudatus*. The basal joint is larger than that of the second legs, and almost circular. The exopod is three-jointed and more than twice the length of the endopod; the three joints are about the same length, the two basal ones with a stout spine at the outer distal corner, and a single plumose seta on the inner margin. The terminal joint has three spines on its outer margin, the last one more than twice the length of the other two, and four spines on the inner margin. The endopod has only two joints of about the same size, the basal one carrying a single plumose seta on its inner margin, the terminal one tipped with three such setæ.

The fifth legs are small and close to the lateral margin on the ventral surface of the genital segment, a little in front of the posterior corners.

The cement glands are comparatively wide and reach forward almost to the anterior end of the segment; their component cells are narrow and fill the entire lumen of the glands. The sperm receptacle is a nearly straight tube of uniform width, reaching across from one oviduct to the other. The spermatophores are elongate-ellipsoidal, and are fastened close together on either side of the mid-line, their long diameters parallel with the body axis (fig. 31).

Total length 5·75 millims., length of carapace (including third thorax joint) 2·5 millims., width of same 2·1 millims., length of genital segment 1·57 millims., length of abdomen 1·1 millims., length of egg-strings 3·1 millims.

Colour of preserved material a uniform yellowish white without pigment spots or lines.

Male.—Carapace ovate and narrowed anteriorly, with grooves and markings on the dorsal surface like those of the female, but it is relatively larger, being more than half the entire length, and nearly as wide as long. The eyes are distinct and small, about one-third the distance from the anterior margin.

The second and third thorax segments are wider than in the female; the fourth segment is the same width as the genital segment and only a trifle longer than the second and third segments. The genital segment is elliptical-oblong, one-fourth longer than wide, and not quite one-fifth of the entire length. Both the fifth and the sixth legs are visible dorsally, the former on the lateral margins at about the centre of the segment, the latter at the posterior corners.

The abdomen is two-jointed and at least one-half shorter than the genital segment; the two joints are equal in size. The anal laminæ are narrow, but nearly as long as the entire abdomen, each tipped with four very long plumose setæ.

Appendages and colour as in the female.

Total length 2·75 millims., length of carapace (including third thorax segment) 1·4 millims., width of same 1·3 millims., length of genital segment 0·5 millim., length of abdomen (including anal laminæ) 0·6 millim.

Developmental stages.—Young females were obtained in two stages of development respectively 2·5 millims. and 3·5 millims. long.

In the former, the second thorax segment is not yet fused with the carapace, but is semilunar in shape, with the convex side projecting a little way into the posterior portion of the carapace. The lateral processes on this segment are nearly as large as the posterior lobes of the carapace (fig. 32).

The third segment is much narrower than the second, but is still wider than it is long. The fourth segment is considerably longer than wide and has a broad spindle shape. In the genital segment each of the posterior angles projects strongly sidewise, is well rounded, and armed with two stout spines. This makes the segment twice as wide across the posterior margin as across the anterior. The abdomen is also slightly wider at its posterior end.

The first antennæ are short and thick and are appressed closely to the margin of the carapace. The other appendages are similar to those of the adult except the swimming legs, in which the rami have but two joints instead of three.

In the later developmental stage the carapace has enlarged considerably, and the second thorax segment has widened with it (fig. 33). The longitudinal and transverse grooves on the dorsal surface of the carapace are now fully formed, so that the same areas are seen as in the adult. The third and fourth thorax segments are about the same as in the previous stage, but the genital segment has changed radically. It has widened into a broad acorn shape, as wide anteriorly as posteriorly, with the posterior corners projecting slightly backwards and showing the fifth

legs plainly at their tips. The abdomen has elongated and its sides are now parallel.

The appendages have assumed their final form, and the rami of the swimming legs have all become clearly three-jointed.

About ten specimens of this species were obtained from *Rhinoptera javanica*, including the two stages of early development. The species is of peculiar interest, because it is the only one besides KRÖYER's original type (*T. caudatus*) of which a full description of even one sex could be obtained.

It confirms KRÖYER's genus diagnosis in all but two particulars. The second maxillæ are not forked at the tip like those of *Lepeophtheirus*, but are simple and pointed like those of *Caligus*. Furthermore the endopod of the fourth legs, instead of being as large as the exopod, is reduced so much as to be rudimentary and contains only two joints. These two particulars furnished data which will at once distinguish the species from *T. caudatus*.

SUB-FAMILY: EURYPHORINÆ.

Dissonus,* n. gen.

First thorax segment fused with the head to form the carapace, which is semilunar in shape and about twice as wide as long.

Second, third, and fourth thorax segments free, each considerably wider than long, the second one only provided with lateral plates. Genital segment not much enlarged, without plates or processes, but with the entire ventral surface covered with stout spines. In the male the fifth legs are seen on the posterior lateral margins and the sixth pair at the posterior corners. Abdomen small, one-jointed in both sexes; anal laminæ of medium size and armed with large plumose setæ.

Egg-strings four-fifths of the entire length and not quite as wide as the abdomen. Eggs large, about forty in each string.

Antennæ and mouth-parts like those in the Caliginæ. Second maxillæ longer than the mouth-tube and bifurcate at the tip. First maxillæ and furca wanting. Mouth-tube short and triangular in shape with a rounded tip, jointed transversely near the centre. The four pairs of swimming legs biramose; rami of the first pair two-jointed, of the other pairs three-jointed; spines and setæ almost exactly like those in *Trebius*.

Dissonus spinifer,† n. sp.—Plate III., figs. 34 to 47.

Female.—Carapace transversely semilunar, twice as wide as long; the ventral surface around and outside of the second antennæ is raised somewhat, and beneath it

* *Dissonus*, disagreeing or different, *i.e*, not agreeing with any of the established genera.

† *Spinifer*, bearing spines (on the ventral surface of the genital segment).

can be seen the powerful muscles which move those appendages, and which radiate outward from the basal joint of the antennæ to the lateral margin of the carapace.

The dorsal surface has but a single pair of grooves, one on either side separating the lateral areas from the central cephalic area. Eyes moderately large, situated close to the anterior margin and in contact with each other on the mid-line, but not fused. In front of the eyes and on the very margin is a pair of elliptical spots, a little larger than the eyes and raised above the surrounding surface like a pair of lenses. These correspond exactly with the so-called "conspicilla" found by DANA in his *Specilligus curticaudis*, and which occur also in the males of other species belonging to the Pandarinæ. They have also been noted by KRÖYER in the male of *Trebius caudatus*, but are not found in the male of the new species of *Trebius* just described. In the present genus they are much farther forward and nearer together, being just in front of the supra-œsophageal ganglion.

The second, third, and fourth thorax segments are free and diminish regularly in size. The second segment is the same width as the body of the carapace and its lateral plates are as wide as the lateral lobes of the carapace. The third and fourth segments are considerably narrowed, but even the fourth is more than twice as wide as long, and the basal joints of the legs attached to both these segments closely resemble in dorsal view the lateral lobes of the carapace and the lateral plates on the second segment.

The genital segment is quadrangular, a little wider than long, and a little narrower than the fourth segment. The processes at the posterior corners are very small, and the fifth legs are almost invisible dorsally. The entire ventral surface of the genital segment is covered with stout scattered spines which point diagonally backward. These are thickest along the sides and must furnish a very effective preventative against slipping, as in the genus *Argulus*.

The abdomen is three-eighths the length of the genital segment, one-fourth wider than long, and one-jointed, with a shallow anal fissure. The anal laminæ are quadrangular-oblong, of medium size, each armed with four large plumose setæ. Three of these are terminal, while the other comes out of the lateral margin near the anterior end.

Of the appendages, the anterior antennæ are large and prominent, two-jointed, with the joints about the same length, but the basal one considerably thickened. Each antenna is one-fourth longer than the frontal plate from whence it comes. The setæ and spines are similar to those in the Caliginæ. The second antennæ are stout and of the same pattern as in *Caligus*. The terminal claw fits into a small pocket made for its reception in the ventral surface of the carapace near the margin (fig. 37).

The first maxillæ and furca are entirely lacking. The mandibles are slender, three-jointed, and armed with hook-like teeth along the inner margin of the slightly curved terminal joint. The mouth-tube is triangular, with a narrow and well-rounded tip; the mouth-opening is terminal and quadrilateral, with a heavy fringe of hairs.

The bony framework is peculiar in its structure, although in some particulars it shows a resemblance to *Caligus rapax* and other Caliginæ. There is in the lower lip a rod (*a*, fig. 38) along either edge, the two meeting in the centre at the distal end. The bases of these rods articulate on the ventral surface of the carapace together with the mandibles. From these articulations a short rod (*b*) extends forward and inward on either side along the ventral surface of the carapace.

From the inner ends of these rods another pair extend upward and inward along the upper lip to the lateral incision opposite the joint (*c*). From these incisions radiate four pairs of rods, three of which (*d*) are in the upper lip, while the fourth pair (*e*) extend downwards on either side to the rod that runs along the edge of the lower lip. Of the three pairs in the upper lip two extend inward side by side, one above and one below the joint, and meet on the mid-line. The lateral incisions at the joint are deeper than in any of the Caliginæ or in *Trebius*, and the mouth-tube must be very flexible.

The second maxillæ are large and powerful; although attached opposite the base of the mouth-tube they reach well beyond its tip. The basal portion of each maxilla is enlarged and flattened, and is about one-third of the entire length. The terminal portion is narrowed abruptly and then tapers gradually to a blunt point, being curved first inward toward the mouth-tube and then outward away from it. At the tip each maxilla is divided into two branches, of which the outer one is the longer and the larger. At the end of the basal portion, where it is abruptly narrowed, there is on the ventral surface a large papilla, from whose summit arise three spines, the outer one twice the length of the other two. These represent the rudiments of the exopod of the maxilla (fig. 39).

The first maxillipeds are of the pattern common to the Caliginæ, the terminal joint two-thirds the length of the basal joint and tipped with two claws, the outer of which is three times as long as the inner.

The second maxillipeds are greatly enlarged, the basal joint stout and swollen and nearly twice the length of the strongly curved terminal claw. On the proximal half of the ventral surface of the basal joint the integument forms a sort of pad with raised edges and a more or less corrugated surface. The distal edge of this pad is raised into a stout knob, down behind which the tip of the terminal claw shuts when closed.

All four pairs of legs are biramose, the rami of the first pair two-jointed, of the other pairs three-jointed. In the first pair the exopod is a little more than twice the length of the endopod. Its basal joint is three times as long as the terminal one, is heavily fringed with hairs along its posterior margin, and ends in a stout spine. The terminal joint is nearly spherical and is attached at right angles to the basal joint, not at the tip, but some distance back on the posterior border. It is armed, as in the Caliginæ, with three terminal spines, three rowing setæ, and a smaller seta at the inner distal corner. The endopod joints are about the same size, the

terminal one armed with four spines on the outer margin and three rowing setæ on the inner.

The second, third and fourth swimming legs are as in other Euryphorinæ and the Trebinæ, particularly in the form of the second joint of the endopod and in the number and arrangement of the spines and setæ. The following table represents the arrangement of spines and setæ on each joint:—

Second legs,	exopod . . .	2–1,	1–1,	1–5.
,,	endopod . . .	0–1,	0–2,	0–6.
Third legs,	exopod . . .	1–1,	1–1,	3–5.
,,	endopod . . .	0–1,	0–2,	1–4.
Fourth legs,	exopod . . .	1–1,	1–1,	3–5.
,,	endopod . . .	0–1,	0–2,	1–3.

The fifth legs appear as small papillæ at the posterior corners of the genital segment, each armed with three setæ.

Of the reproductive organs the cement glands are rather small, broadly club-shaped, and they reach but little in front of the centre of the genital segment. The component cells are of medium size and there are about twelve in each gland. The semen receptacle is very close to the posterior margin; it is considerably curved, with the concave side directed forwards. The ends are slightly enlarged and from each a duct runs forward and empties into the oviduct anterior to the opening of the cement gland.

Colour of preserved specimens a uniform yellowish white without pigment spots or lines.

Total length 3 millims., length of carapace 0·85 millim., width of same 1·75 millims., length of free thorax 1·1 millims., length of genital segment 0·71 millim., of abdomen 0·34 millim., of egg-strings 2·35 millims.

Male.—Similar to the female in general appearance and in most of the details of structure. Carapace transversely semilunar, a little more than twice as wide as long. Second, third and fourth thorax segments diminishing slightly in width, but increasing in length, the fourth segment nearly one-half longer than the second. Second segment the only one furnished with lateral plates, but the large basal joints of the third and fourth legs have all the appearance of lateral plates in dorsal view, as in the female.

Genital segment elongate-spindle-shaped, one-third longer than wide, with evenly rounded sides; the anterior margin re-entrant, the posterior one nearly squarely truncated. Two pairs of rudimentary legs are visible, one pair on the lateral margin about one-fourth the distance from the posterior end, and the other pair at the posterior corners.

Abdomen not as wide as in the female, the anal laminæ a little smaller, but the plumose setæ considerably larger.

Of the appendages, the second antennæ are especially large and stout; their terminal claw is bent abruptly at a right angle one-third its length from the tip, and is armed on the inner margin of the basal third with a long curved and sharp spine, a short and blunt one, and a long slender hair (fig. 36). The second maxillæ are similar to those of the female but larger and more powerful. The outer branch at the tip is nearly twice as long as the inner, while the three spines which make up the rudimentary exopod are much larger and stouter. The maxillipeds and legs are the same as in the female. The ventral surface of the genital segment is also covered with spines, larger and rather more numerous than in the female (fig. 47).

Total length 3 millims., length of carapace 0·8 millim., width of same 1·9 millims., length of free segments 1·08 millims., of genital segment 0·8 millim.

This new genus is very interesting since it stands as a connecting link between the Euryphorinæ and the Pandarinæ. At first sight it would be taken for a *Nogagus* species, showing that which was so long sought after, a mature female with her egg-strings. But the description just given excludes it from that genus. The dorsal aspect, to be sure, is very similar to that of a typical *Nogagus*; the carapace is perhaps a little too short, but the free segments, the genital segment, and the abdomen are almost identical with those in some species of *Nogagus*. When we examine the ventral surface and the appendages, however, we find radical differences.

First there are no traces of sucking disks which are found in all the species of *Nogagus*. The mouth-tube, mandibles and second maxillæ are like those found in the Euryphorinæ and quite different from the typical form of the Pandarinæ.

The mouth-tube is short and broadly rounded at the tip instead of being narrow and pointed. The mandibles are curved at the tip, toothed on the concave border, and come together end to end, instead of being straight, with the toothed margins interlocked for their entire length. The second maxillæ are very long, pointed, and bifurcate at the tip, with a well defined exopod, instead of being short, triangular or broadly laminate, and without any trace of a second ramus.

The second maxillipeds have a simple swollen basal joint and an ordinary terminal claw unlike the distorted form in *Nogagus* with its swellings and knobs.

The swimming legs have three-jointed rami, except those of the first pair; a typical *Nogagus* has no ramus with more than two joints. We have here then a genus whose body-form is almost exactly like that of *Nogagus*, while its appendages are all modified and approach much nearer to those found on *Euryphorus*, *Alebion*, and *Dysgamus*. And since in any systematization, but more especially here among the Parasitic Copepods, the appendages are of more value than the body form in determining relationship, this genus must be placed with the Euryphorinæ.

It will be the only genus in the sub-family possessing three free thorax segments, but as it is an intermediate form, any close conformity to the characteristics of a single family could not be reasonably expected.

FAMILY: DICHELESTIIDÆ.

Cætrodes,* n. gen.

Body regions distinct. Head covered with a dorsal carapace which is obovate in shape, strongly arched and considerably widened anteriorly, narrower and rounded posteriorly. This posterior portion is flattened and projects far back over the thorax segments, but is not attached to them. Frontal margin turned under the carapace a little, carrying the base of the anterior antennæ back with it on the ventral surface.

At least four (probably five) free thorax segments, indistinctly separated and diminishing in width posteriorly, the fifth one sending back a wide lobe on either side of the genital segment. Genital segment small, transversely oblong, enclosed on three sides by the fifth segment.

Abdomen small, hemispherical, one-jointed. Anal papillæ longer than the abdomen, narrow, cylindrical, and terminating in a spine and a claw.

First antennæ five-jointed, slender, with very few setæ except on the terminal joint. Second pair stout, ending in a prehensile claw. Mouth-tube short and wide; mouth-opening terminal.

First maxillipeds rudimentary, attached close beside the second maxillæ and of about the same size. Second pair slender, two-jointed. Two pairs of biramose swimming legs, close together and just behind the second maxillipeds; rami linear and two-jointed. Egg-tubes longer than the body; eggs large and uniseriate.

Cætrodes pholas,† n. sp.—Plate IV., figs. 48 to 57.

Female.—Head wider than the rest of the body and two-fifths of the entire length; covered dorsally with a strongly arched carapace which is divided into right and left halves by a prominent ridge or rib at the centre. The posterior margin of this carapace is prolonged backward in the form of a thin flattened plate which covers the anterior half of the thorax segments.

With the point of a needle, or by sharply flexing the body, this plate may be lifted away from the thorax segments, and this shows that it is not attached to them in any way. There is no trace of the median rib in this posterior part of the carapace. The passage from the arched to the flattened portion of the carapace is very irregular and forms a broken line over the posterior margin of the head. At the centre there is a wide triangular sinus extending forward, with its point on the median line. On either side of this is a blunt, rounded projection extending backward, outside of which is a wavy line curving forward as it runs toward the margin. There are no traces of frontal plates or of eyes.

The thorax is composed of at least four (probably five) free segments, which are imperfectly separated from one another.

* *Cætrodes*, like a small round shield.

† *Pholas*, lurking in a hole or burrow.

The first two of these are very short and considerably narrower than the head; the third and fourth (fused) are longer and wider, and together are about three-fifths the size of the carapace shield. The fifth segment is shorter and narrower than the fourth. It is divided transversely into thirds, the two outer divisions extending backwards in the form of wide rounded lobes on either side of the genital segment and abdomen, the median division forming a shallow rounded sinus for the attachment of the genital segment.

The genital segment and abdomen together form a hemisphere about the size of one of the posterior lobes of the fifth segment. The abdomen is one-jointed and bears on its ventral surface, at the posterior margin, two large cylindrical anal papillæ. These are longer than the abdomen itself, and each is tipped with a claw and a spine. The claw, which is on the inside, is nearly as long as the papilla, stout, and abruptly curved near the tip, exactly like the prehensile claws on the second antennæ of the Caligidæ. The spine is only one-fourth as long as the claw, and straight (fig. 57).

Egg-tubes wider than the genital segment and one-third longer than the entire body; eggs large, about 30 in each tube.

The first antennæ are five-jointed, the joints diminishing in diameter towards the tip; the setæ are very scattered except on the third and last joints. The second antennæ have a stout and conical basal joint, and a slender, strongly-curved terminal claw.

The mouth-tube is short and wide, with a rather blunt tip, enclosing the slender mandibles which are toothed on their inner margins. The second maxillæ and first maxillipeds are about the same size and close together at the sides of the mouth-tube. Each is two-jointed, and is made up of a short and plump basal joint and a slender terminal spine. The maxillipeds, of course, are rudimentary when reduced to this size, and are similar to those found in *Pseudoclavella*, *Cycnus*, *Cybicola*, and other Dichelestiids (fig. 52).

The second maxillipeds are fairly developed and much resemble the first pair in the Caligidæ. They are two-jointed, the joints about the same length, the terminal one tipped with a short and straight claw.

There are only two pairs of swimming legs, both biramose, with the rami linear and two-jointed. In each pair the exopod joints are about the same length, while the basal joint of the endopod is much shorter than the terminal.

Owing to the habit which the species has of lying in a burrow, the oviducts open on the dorsal surface, on either side of, and quite near to, the mid-line. The ovaries and the internal portions of the oviducts fill the entire thorax and even project forward into the head. The external portions (egg-tubes) start out at right angles to the dorsal surface, and are thus lifted well above the edge of the burrow. They then curve over and lie in close contact with the surface of the fish's gill outside the burrow (fig. 48).

Colour of the entire animal, a deep reddish yellow, like that of the gill on which it lives. The two arched halves of the anterior portion of the carapace are almost white, and the uneven line, where the arched portion passes into the flattened plate, stands out prominently in consequence of the meeting of this white colour with the deep yellow.

Total length 1·15 millims.; length of carapace 0·9 millim.; length of head 0·5 millim., width of same 0·9 millim.; length of thorax 0·65 millim.; length of egg-strings 1·8 millims.

This Dichelestiid is particularly interesting on account of its peculiar burrowing habit. About fifteen specimens, all females, were obtained from the gill filaments of *Tetrodon stellatus*. After fastening themselves to the surface of the filament by the prehensile second antennæ, and, we strongly suspect, by the terminal hooks on the anal laminæ, these parasites in some way irritate the epithelium until it is raised into a broad fold or flap, entirely surrounding the Copepod's body and overlapping its margin on all sides. A small convex mound is thus formed, beneath the open centre of which lies the body of the parasite, its egg-tubes projecting freely and lying along the surface of the gill filament. The anterior margin of the head and the posterior extremity of the body, including the abdomen and anal laminæ, are burrowed under the edge of the epithelium fold and fastened by their prehensile hooks.

Apparently, therefore, the parasite can have no freedom of motion, but is fastened immovably in place. No similar case of burrowing is known to the author; there are, of course, many genera among the Chondracanthidæ and Lernæidæ which bury the head and neck in the flesh of their host. There are also genera of the Dichelestiidæ, such as *Anthosoma*, *Eudactylina*, and the like, whose prehensile claws irritate the epithelium of the host until it grows up in a fold over the claws themselves.

But so far as is known, this is the only case where the epithelium folds entirely surround the body, so that the latter is securely held in place by them. The result is that the body of the parasite lies in the bottom of a hole or burrow, with only a portion of its dorsal surface visible.

Hatschekia, ? n. sp.—Plate V., figs. 58 to 60.

A single specimen of a species belonging to this genus was obtained from the stomach of *Carcharias mülleri*. It was a young female without egg-strings but with spermatophores, and was only a trifle over 1 millim. in length.

While it seems to be a new species unlike any thus far described, yet its small size, its poor condition, and the manifest fact that it is not a fully developed adult furnish sufficient reasons to prevent its establishment as a new species. The following description and the figures which accompany it must await future confirmation, therefore, before being finally established.

Female.—Head transversely elliptical, one-half wider than long, one-fifth the entire length. Thorax composed of two free joints and the genital segment. First

free joint a little narrower than the head, second joint and genital segment considerably wider. The latter sends out a blunt rounded process on either side of, and nearly as large as, the abdomen. No appendages are visible on these processes or elsewhere on the genital segment. Abdomen very small and nearly spherical, with a pair of minute anal papillæ, each of which ends in three small setæ. First antennæ slender and apparently six-jointed; second pair large and terminated by a stout prehensile claw. Mouth-tube short and narrow and bluntly rounded at the tip; second maxillæ and first maxillipeds in the form of two small papillæ on each side of the mouth-tube, each tipped with a single seta. Second maxillipeds slender, the terminal joint shorter than the basal. Two pairs of biramose legs placed close behind the second maxillipeds; basal joints rounded and flattened laminæ, rami linear and cylindrical; exopods two-jointed, endopods one-jointed. Spermatophores comparatively very large and attached by long delivery ducts.

Colour a pale yellow, the ovaries and internal oviducts showing a dark brown through the transparent integument.

Total length 1·07 millims.; length of free thorax 0·35 millim.; length of genital segment 0·5 millim., width of same 0·48 millim.

Family: LERNÆIDÆ.

Peniculus, Nordmann.

Head oval or elliptical, elongate, without horn-like processes, connected with the body by a short and narrow neck, which is made up of two distinct thorax segments. Body a fusion of several thorax segments, elongate, wider than the head, and sometimes prolonged posteriorly into two elongate flattened processes.

Abdomen small, consisting of a single joint and carrying minute anal papillæ, which are tipped with non-plumose setæ. Egg-strings filiform; eggs large and uniseriate.

First antennæ reduced to mere knobs; second pair large and chelate, projecting in front of the head and forming the chief organs of prehension. Mouth a simple tube projecting from the ventral surface of the head; mouth-parts entirely wanting, except a single pair of very rudimentary maxillipeds beside the mouth tube. Four pairs of rudimentary swimming legs; first two pairs placed close behind the head, third and fourth pairs some distance from them and from each other.

Male smaller than the female and with a shorter thorax; posterior processes also shorter than those of the female, but wider and truncate at the tip.

Peniculus furcatus, Kröyer—Plate V., figs. 61 to 66.

Female.—Head elliptical, slightly widened posteriorly, about twice as long as wide, with evenly curved sides. Posteriorly the head passes into a neck of about half its width, made up of three thorax segments which are distinctly separated on both the ventral and dorsal surfaces. The fourth and genital segments are fused, with no line

of demarkation except the position of the fourth legs on the ventral surface. This fused portion constitutes the body of the Copepod, which is nearly twice the width of the head, and twice as long as wide, with parallel sides.

The body widens sharply from the neck, its anterior corners well rounded, while its posterior corners are produced into a pair of wide, flattened processes, nearly as long as the rest of the animal, and either straight or slightly divergent, Along the sides, toward the centre, these processes often show incisions and grooves, very irregularly placed in different specimens and suggesting imperfect segmentation.

Between the bases of these processes lies the small abdomen, a little wider than the processes, and also a little wider than long. Its posterior corners are produced into short and rounded processes, similar to those on the genital segment but much smaller. Between these processes on the posterior margin are the tiny anal papillæ, each of which terminates in three non-plumose setæ. Of these latter, the inner and outer ones are considerably longer than the middle one (fig. 66).

The first antennæ are reduced to mere knobs, so rudimentary as to be invisible unless seen in profile and under the best conditions. The second pair are much enlarged and extend forward diagonally in front of the head. They are the organs of prehension and consist of an enlarged basal joint filled with strong muscles, and a stout terminal claw which is buried in the flesh of the host. The basal joints are united throughout their entire length, and are enlarged at the end into a double disc, from the edge of which on either side project the terminal claws. The mouth-tube is a simple hollow cone projecting but little from the ventral surface; the mouth-parts have all been aborted, with the exception of the second maxillipeds. These appear as tiny two-jointed appendages on either side of the base of the mouth-tube (fig. 64).

There are four pairs of rudimentary legs, the first three of which are close together on the thorax segments which form the neck, while the fourth pair are some distance farther back on the ventral surface. We may presume that the line of junction of the fourth and genital segments is just behind the bases of these legs. Each leg consists of a triangular basal lamina tipped with two minute, one-jointed rami scarcely larger than spines, and naked.

Colour a dark grey by reflected light, a greyish yellow by transmitted light. Under the latter conditions spots of dark pigment are seen along the sides of the head and neck, at the posterior end of the genital segment, and along the centre of the posterior processes. The two oviducts also show through the dorsal surface of the genital segment as two broad lines of dark brown, broken up into separate spherical eggs.

Total length 2·35 millims., length of head 0·35 millim., length of genital segment 0·79 millim., length of posterior processes 1 millim., length of egg-strings 0·6 millim., width of genital segment 0·4 millim.

Male.—Similar to the female, but with certain marked differences in the body

proportions. The head and free thorax segments are about the same, but the genital segment is relatively longer and narrower, being nearly half the entire length.

The posterior processes are only one-third as long as in the female, and are spathulate, being somewhat enlarged and strongly flattened at the tips. Their width at the tip is three-fifths of their length, while in the female it is less than one-seventh. The abdomen lacks the posterior processes, and is nearly hemispherical in shape; the anal papillæ are relatively larger, and their setæ, also non-plumose, a trifle longer.

Colour the same, except that there are no pigment spots on the posterior processes, and there are two narrow lines of pigment parallel to the sides of the genital segment in place of the wide broken lines of eggs seen in the female.

Total length 1·6 millims., length of head 0·35 millim., length of genital segment 0·71 millim., length of posterior processes 0·35 millim., width of genital segment 0·3 millim.

This species was founded by Kröyer upon a single female obtained by exchange from the Vienna Museum. And Kröyer himself states that this specimen was imperfect, so that the description given was necessarily incomplete. This original type specimen was obtained from a species of *Holacanthus* (*Tetrodon*) taken in the Indian Ocean.

The present lot of material is from the same region and was found on the same genus of fish (*Tetrodon*)—whether upon the same species or not, is impossible to tell, since Kröyer does not name the species. The specimens include some twenty females and two males, nearly all of which are in excellent condition. We are thus justified in supplementing Kröyer's description, and in presenting a complete account of both sexes with accurate figures. A genus diagnosis is also here given for the first time (p. 206).

EXPLANATION OF THE PLATES.

PLATE I.—*Lepeophtheirus brachyurus*, Heller, and *Lepeophtheirus æsopus*, n. sp.

Fig. 1. *Lepeophtheirus brachyurus*, dorsal view of female.
,, 2. First and second antenna and first maxilla.
,, 3. Mouth-tube and second maxillæ.
,, 4. Second maxilliped.
,, 5. Furca.
Figs. 6 to 9. First, second, third, and fourth swimming legs.
Fig. 10. Genital segment, ventral surface, showing cement glands and sperm receptacle.
,, 11. *Lepeophtheirus æsopus*, dorsal view of female.
,, 12. Second antenna and first maxilla.
,, 13. Mouth-tube and second maxillæ.
,, 14. Second maxilliped.
Figs 15 to 18. First, second, third, and fourth swimming legs.
Fig. 19. Ventral surface of genital segment, showing cement glands and spermatophores.

PLATE II.—*Trebius exilis*, n. sp.

Fig. 20. Dorsal view of adult female.
,, 21. ,, ,, male.
,, 22. Second antenna of male.
,, 23. Mouth-tube and second maxilla.
,, 24. First maxilliped.
,, 25. Second maxilliped.
,, 26. Furca.
Figs 27 to 30. First, second, third, and fourth swimming legs.
Fig. 31. Ventral surface of genital segment, showing the cement glands and spermatophores.
Figs. 32 and 33. Dorsal views of young females in different stages of development.

PLATE III.—*Dissonus spinifer*, n. gen. et n. sp.

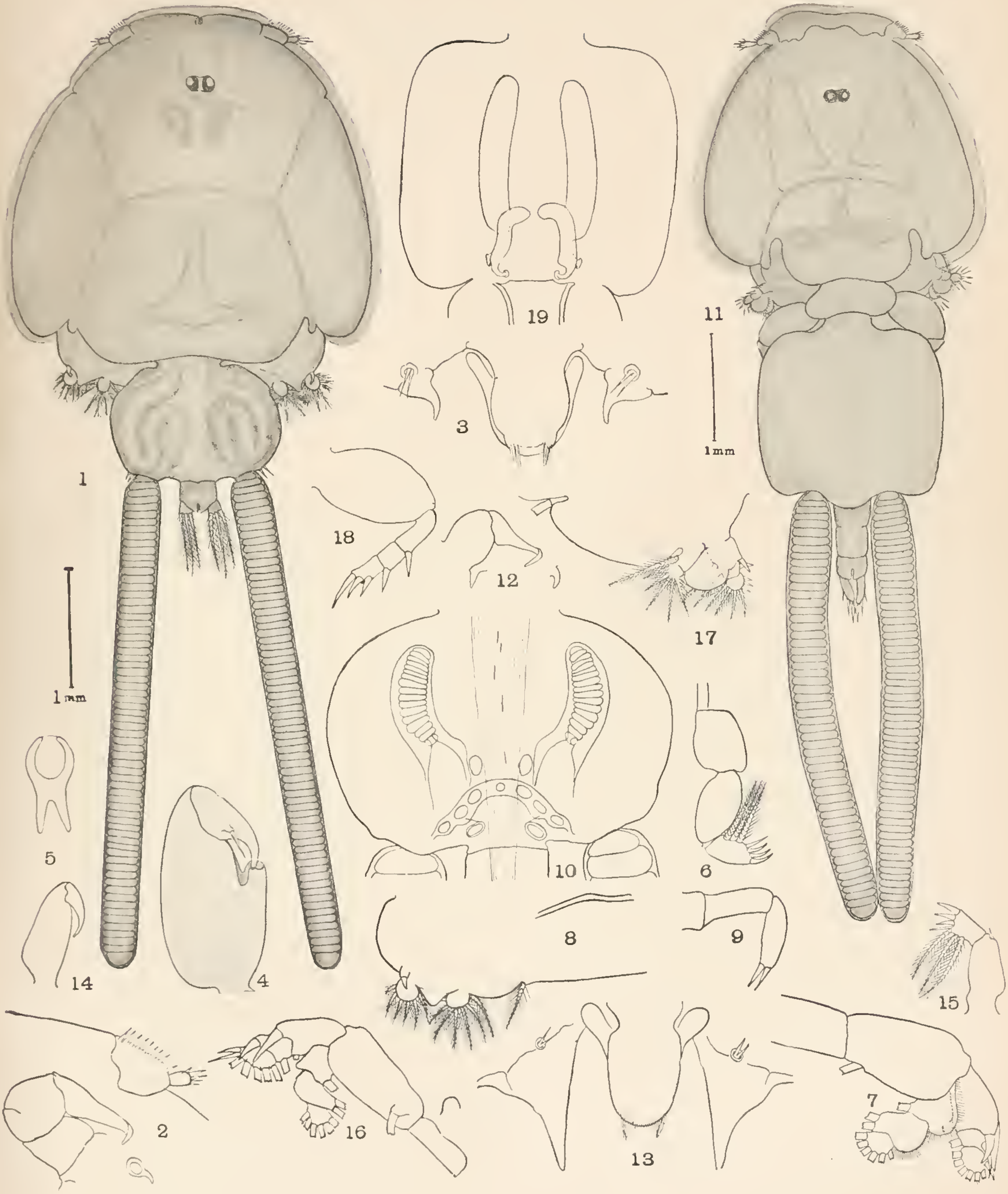
Fig. 34. Dorsal view of female.
,, 35. ,, ,, male.
,, 36. Second antenna of male.
,, 37. Ventral view of anterior part of carapace, showing relative size and position of antennæ and mouth-parts.
,, 38. Bony frame work of mouth-tube, and the second maxillæ.
,, 39. Second maxilla of male.
,, 40. Mandible.
Figs. 41 and 42. First and second maxillipeds.
,, 43 to 46. First, second, third, and fourth swimming legs.
Fig. 47. Ventral surface of genital segment of male.

PLATE IV.—*Cœtrodes pholas*, n. gen. et n. sp.

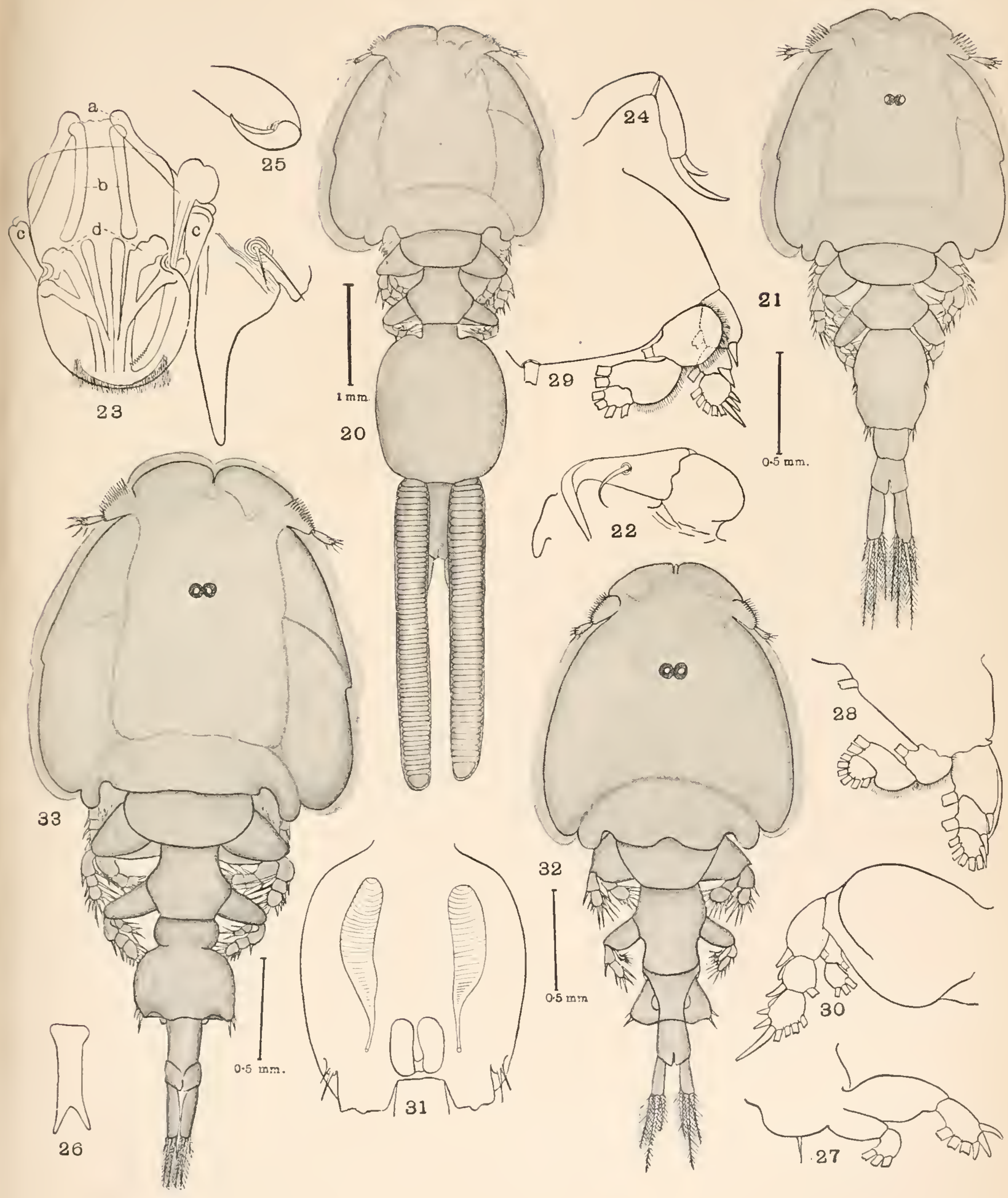
Fig. 48. Dorsal view of female in its burrow on a gill filament.
,, 49. ,, ,, same female removed from its burrow (enlarged).
,, 50. First antenna.
,, 51. Second antenna.
,, 52. Mouth-tube, second maxilla (*a*), and first maxilliped (*b*).
,, 53. Second maxilliped.
Figs. 54 and 55. First and second swimming legs.
,, 56 ,, 57. Dorsal and ventral views of genital segment and abdomen.

PLATE V.—*Hatschekia* sp. and *Peniculus furcatus*, Kröyer.

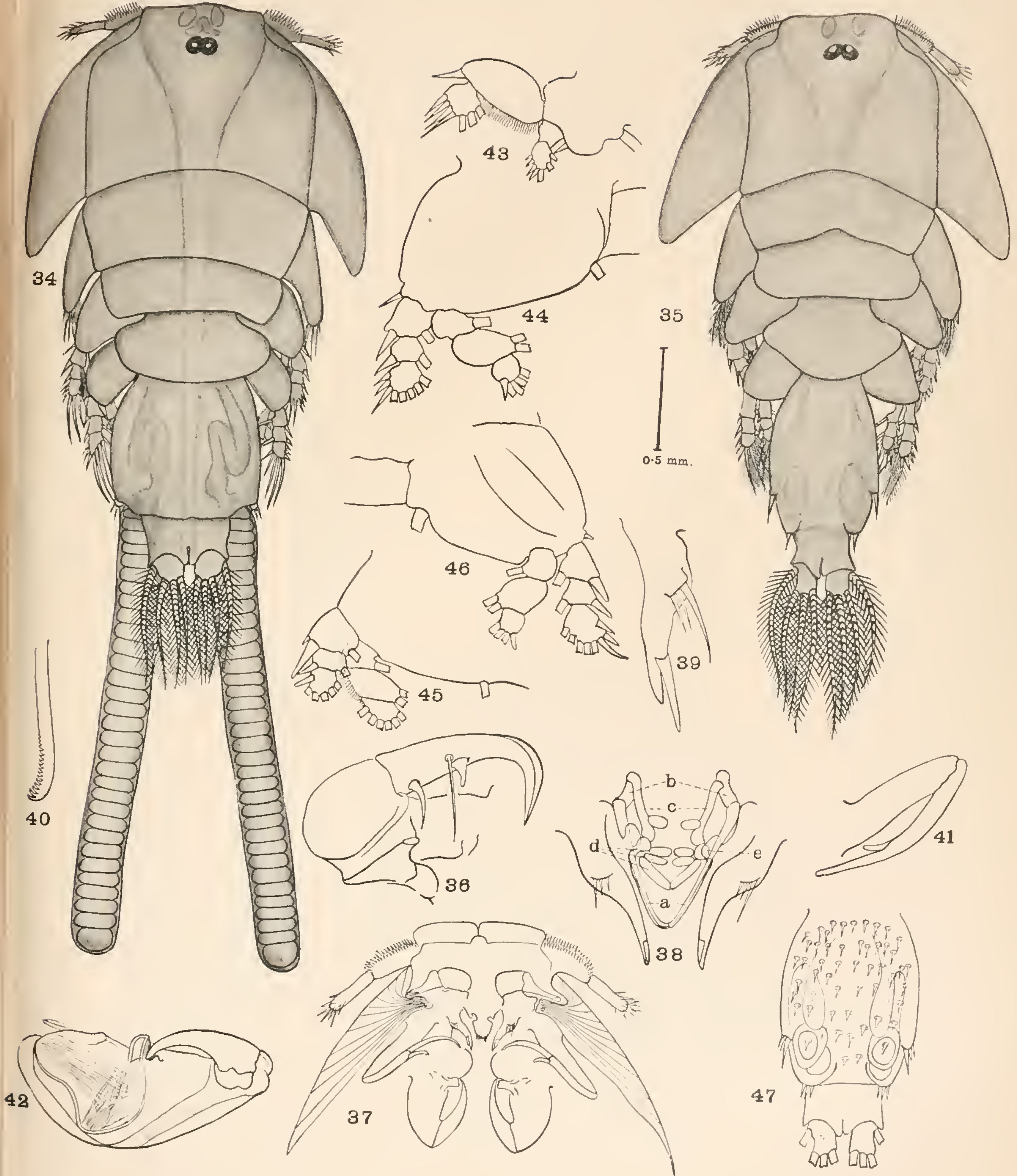
Fig. 58. Dorsal view of *Hatschekia* sp., female.
,, 59. Ventral view of head and first two thorax segments, showing (*a*) first antenna; (*b*) second antenna; (*c*) second maxilla; (*d*) first maxilliped; (*e*) second maxilliped; (*f*) first swimming leg; (*g*) second swimming leg.
,, 60. Ventral view of abdomen, showing anal papillæ and spermatophores.
,, 61. Dorsal view of female of *Peniculus furcatus*, Kröyer.
,, 62. Ventral view of same, showing egg-cases.
,, 63. Dorsal view of male.
,, 64. Profile view of head, showing (*a*) rudimentary first antenna; (*b*) prehensile second antennæ; (*c*) rudimentary second maxillipeds.
,, 65. End view of fused second antennæ, showing the terminal claws.
,, 66. Ventral view of abdomen of female.



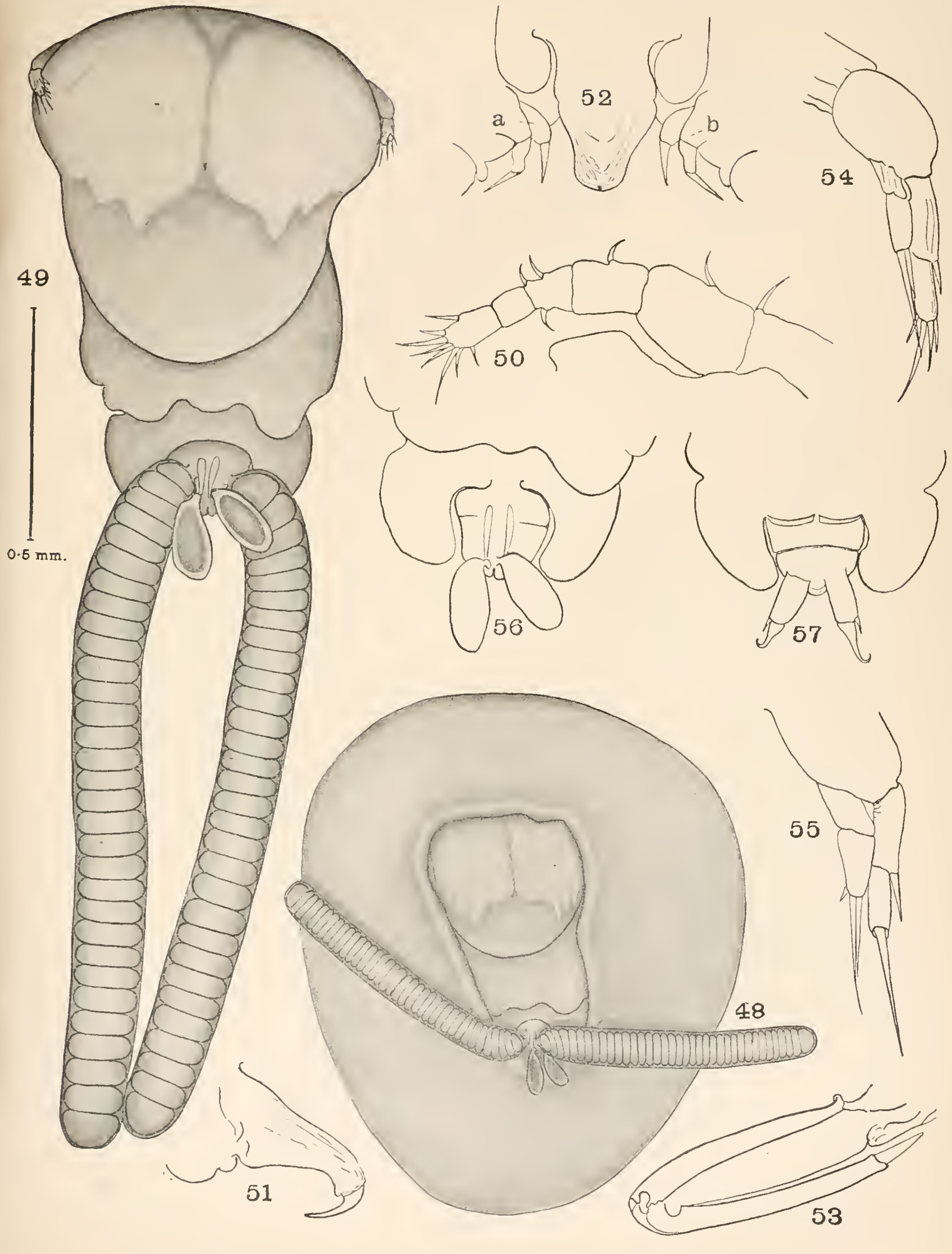
FIGS. 1—10, LEPEOPHTHEIRUS BRACHYURUS, HELLER.
FIGS. 11—19, LEPEOPHTHEIRUS AESOPUS, N.SP.



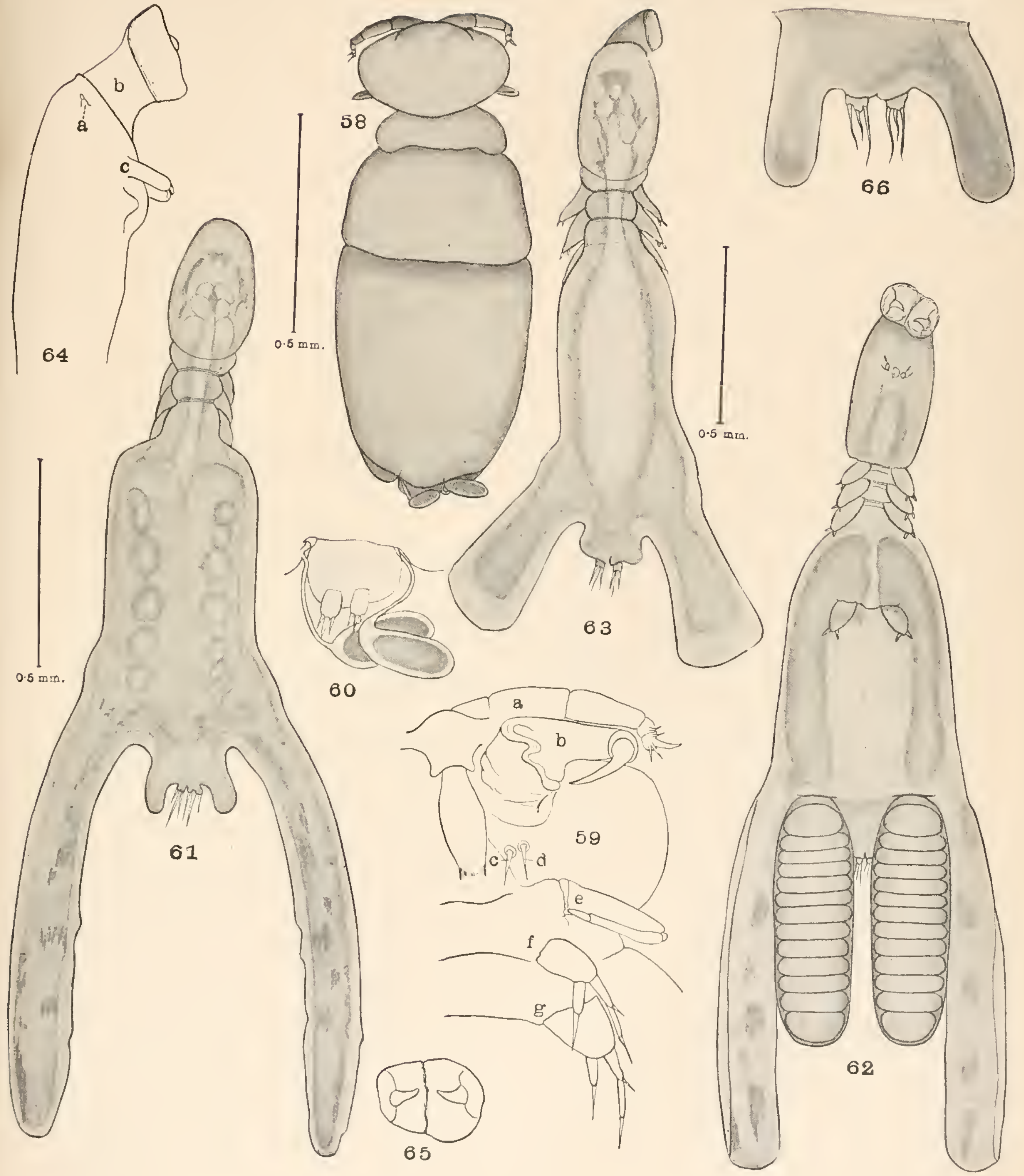
TREBIUS EXILIS, N.SP.



DISSONUS SPINIFER, N.GEN. & SP.



CAETRODES PHOLAS, N.GEN. & SP.



FIGS. 58—60, HATSCHEKIA SP.

FIGS. 61—66, PENICULUS FURCATUS, KRÖYER.

REPORT

ON THE

ANOMURA

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

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[WITH TEXT-FIGURES.]

THIS collection of Anomura, entrusted to me for description by Professor HERDMAN—whose kind help in many ways I desire to acknowledge here—comprises 48 species, distributed amongst 22 genera. Two of these species, viz., *Munida alcocki* and *Porcellana hornelli*, are new to science, and a number of others are new to the marine fauna of Ceylon, and add considerably to our knowledge of the geographical distribution of the group.

The Anomuran fauna of this region of the world has been made known chiefly through the descriptions (1) by HENDERSON of the material collected in the Gulf of Manaar by THURSTON, and (2) by ALCOCK of the collections made during the cruises of the "Investigator," and contained in the Indian Museum. In all, about 52 species have now been recorded from the seas around Ceylon, and the present collection adds 23 more species to that list, in addition to the two new species cited above. The species collected by the "Investigator" and described by ALCOCK are, in many cases, deep-water forms, while the following is a list of the collection made by THURSTON, and described by HENDERSON (8), from shallow water in the northern part of the Gulf of Manaar, the exact locality where the bulk of the present collection was obtained. It will be of interest for comparison with the list in the pages that follow :—

Dromidia unidentata (RÜPP).
,, *australiensis*, HASWELL.
Cryptodromia pentagonalis, HILG.
Pseudodromia integrifrons, HEND.
Raninoides serratifrons, HEND.
Hippa asiatica, MILNE-EDW.
Albunea symnista (LINN.).
* ,, *thurstoni*, HEND.
**Coenobita rugosa*, MILNE-EDW.
**Diogenes diogenes* (HERBST).
* ,, *merguiensis*, DE MAN.
* ,, *miles* (HERBST).
,, *custos* (FABR.).
,, *planimanus*, HEND.
,, *avarus*, HELLER.
* ,, *costatus*, HEND.
**Pagurus punctulatus* (OLIV.).
,, *deformis*, MILNE-EDW.
Pagurus varipes, HELLER.
* ,, *setifer*, MILNE-EDW.
**Troglopagurus manaarensis*, HEND.
**Aniculus aniculus* (FABR.).
* ,, *strigatus* (HERBST).
**Clibanarius padavensis*, DE MAN.
,, *arethusa*, DE MAN.
**Eupagurus zebra*, HEND.
Petrolisthes dentatus (MILNE-EDW.).
,, *boscii* (AUD.).
* ,, *militaris* (HELLER).
Porcellanella triloba, WHITE.
**Polyonyx obesulus*, MIERS.
,, *tuberculosis*, DE MAN.
**Galathea elegans*, WHITE.
,, *spinosirostris*, DANA.
Munida spinulifera, MIERS.

Of the above 35 species, Professor HERDMAN found the 16 marked with a star, and also 32 additional species which were not obtained by THURSTON.

ANOMURA.

HIPPIDEA.

FAMILY: HIPPIDÆ.

Remipes testudinarius, LATREILLE. (See MIERS, 10.)†

Galle, Station XXXVII., depth 7 fathoms; one specimen measuring 5·5 centims. in extreme length, and six smaller ones of 2 centims. Not previously recorded from Ceylon.

Mastigochirus gracilis (STIMPSON). (See MIERS, 10.)

Galle, Station XL., depth 34 fathoms. Three small male specimens. Not previously recorded from the Indian Ocean.

FAMILY: ALBUNEIDÆ.

Albunea thurstoni, HENDERSON (8).

Localities:—(1) Galle, Station XL., 34 fathoms; (2) off Mutwal Island, Station LXVI., 10 to 35 fathoms; (3) west of Periya Paar, Station LV., 24 fathoms; (4) on Aripu coral reef, shallow water. One specimen from each locality. The carapace of the largest specimen measures 1·6 centims.

† These numbers refer to the literature cited at the end.

PAGURIDEA.

Family: COENOBITIDÆ.

Coenobita clypeatus, Latreille. (See Alcock, 1.)

On Watering Point, Galle, Station XXXVII. One large male, carapace measuring 4·5 centims. This is a common form in the Indian Ocean, but apparently has not been previously recorded from Ceylon.

Coenobita rugosus, Milne-Edw. (See Alcock, 1.)

Localities:—(1) Foul Point, Trincomalee, Station XXV.; (2) on Watering Point, Galle, Station XXXVII.; (3) Kattanattu Point, on shore; (4) Welligam Bay, Station XXXIV., on shore.

The collection contains a large series of this common species, many of which are females bearing eggs. The average length of the carapace is 3 centims. The specimens from Watering Point at Galle, Kattanattu Point in the Gulf of Manaar, and near Mirissa in Welligam Bay, were collected in rough ground at the top of the beach. Professor Herdman's notes contain the following sentences in regard to Welligam:—"Pagurids of several species, some inhabiting the shells of Helix and other land Molluscs, were very common on the upper part of the beach and in the cocoa-nut plantations beyond. A crowd of several dozen were found congregated upon a small heap of dung, evidently feeding. Others were sheltering in numbers about the roots of the trees."

All the specimens, however, belong to *C. rugosus*, and the shells they inhabit have been identified by Mr. R. Standen, as follows:—*Ranella bufonia*, *Ranella granifera*, *Littorina scabra*, *Nassa* sp., *Sistrum spectrum*, *Sistrum* sp., *Turbo argyrostoma*, *Purpura persica*, *Nerita* sp., *Trochus* sp., *Cantharus* sp., *Rapana bulbosa*, *Murex trilobus*, *Pyrula vespertilio*, *Natica* sp., *Natica monile*, *Ampularia* sp., *Helix hæmastoma*, *Cyclophorus menkianus*, *Tritonidia nodosa*.

Family: PAGURIDÆ.

Diogenes investigatoris, Alcock (1).

Localities:—(1) Gulf of Manaar, under 10 fathoms; (2) Palk Bay, Station XVIII., 7 to 8 fathoms. Several small specimens. Carapace measuring about 5 millims. Found inhabiting shells of *Minolia* sp., *Ranella argo*, and *Buccinum pusilla*. This is a new record for Ceylon.

Diogenes rectimanus, Miers (12).

Localities:—(1) On coral reefs and pearl banks in Gulf of Manaar; (2) off Foul Point, Trincomalee, Station XXV., 8 fathoms. Six specimens found inhabiting shells of *Minolia terebra*, *Minolia* sp., *Terebra duplicata*, *Sistrum spectrum*, *Eburna caniculata*, and *Cancellaria antiquata*. This is a new record for Ceylon.

10 fathoms; (2) west of Periya Paar, Station LXI., 12 fathoms; (3) Periya Paar Karia, Station LXII., 7 to 13 fathoms. This species, like the preceding one, was fairly abundant. The carapace of the largest measured 3 centims. The specimens were found inhabiting shells of *Dolium marginalis*, *Natica melanostoma*, *Natica* sp., *Ranella bufonia*, *Ranella crumera*, *Cerithium columba*, *Triton angulatus*, *Sistrum spectrum*.

Pagurus punctulatus, OLIVIER. (See ALCOCK, 1.)

Two male specimens, one from Station XXXIX., off Galle, depth 16 to 30 fathoms, and the other from the coral lagoon at Galle. Carapace measured 3·2 centims.; eye stalks of a maroon-red colour; chelipeds, legs, and carapace red, the latter with numerous whitish ocelli.

Clibanarius padavensis, DE MAN (9).

One female with eggs, from Lake Tampalakam, carapace measuring 2 centims.; also two male specimens having carapace measuring 2·2 centims., from Gulf of Manaar, in shells of *Purpura coronata* and *Natica* sp.

Clibanarius æquabilis, var. **merguiensis,** DE MAN (9).

Localities:—(1) Galle coral lagoon, shallow water; two males, carapace measuring 1·6 centims.; (2) Trincomalee, Station XXIII., 4 to 8 fathoms; one specimen in shell of *Cerithium maurus*.

Calcinus elegans (MILNE-EDW.). (See ALCOCK, 1.)

Locality:—Off Galle, Station XXXVII., 7 fathoms; and also on the shore at Galle. One female and two male specimens, in shells of *Purpura persica* and *Ricinula horrida*. This is a new record from Ceylon.

Calcinus gaimardi (MILNE-EDW.). (See ALCOCK, 1.)

Locality:—Gulf of Manaar, under 10 fathoms. Four male specimens; carapace measuring 9 millims.; in shells of *Latirus nodosus* and *Cerithium* sp. This is a new record for Ceylon.

Aniculus aniculus (FABR.). (See ALCOCK, 1.)

Locality:—Lake Tampalakam, Trincomalee, shallow water. Two specimens; carapace measuring 5½ centims.

Aniculus strigatus (HERBST). (See ALCOCK, 1.)

Localities:—(1) Pearl banks and coral reefs in Gulf of Manaar, under 10 fathoms; (2) Palk Bay, Station XIX., 4 to 8 fathoms; (3) Aripu coral reef, shallow water. In all about 13 specimens, including three females with eggs; carapace of largest measured 2 centims.; found inhabiting shells of *Strombus succinctus*, *Strombus auris-*

10 to 14 fathoms. Fifteen specimens in all; two of the specimens were females bearing eggs; carapace of largest measured 2 centims; found inhabiting shells of *Cerithium citrinum*, *Ranella granifera*, *Cancellaria* sp., *Turbo* sp., *Cerithium*, 2 spp., *Seraphs terebellum*, *Pleurotoma* sp., *Triton* sp., *Strombus elegans*.

Cancellus investigatoris, ALCOCK (1).

Locality:—Gulf of Manaar, shallow water. One specimen; carapace measuring 1·5 centims.

Nematopagurus muricatus, HENDERSON. (See ALCOCK, 1.)

Localities:—(1) Gulf of Manaar, shallow water; (2) near Chilaw Paar, Station IV., 9 fathoms. One male from each; carapace measuring 5 millims.

Nematopagurus sp.

Locality:—Gulf of Manaar, shallow water. A damaged male specimen, without chelipeds and legs; carapace measuring 6 millims; cornea but little dilated; antennal acicle curved and setose, and as long as the eye peduncles; ophthalmic scales well separated; rostrum small, obtuse, and rounded, projecting but little; the ophthalmic peduncles reach the middle of the terminal joint of the antennular peduncles; vas deferens protruding on both sides, the right one being much the longer.

The character of the vas deferens shows that this form belongs to the genus *Nematopagurus*, but, in the absence of all the appendages, I cannot venture to identify it further.

Troglopagurus manaarensis, HENDERSON (8).

Locality:—Coral reefs, Gulf of Manaar, shallow water. Two specimens; carapace measuring 1 centim.

Troglopagurus jousseaumii, BOUVIER. (See ALCOCK, 1.)

Locality:—Pearl banks, Gulf of Manaar, shallow water. Five specimens; carapace measuring 7 millims. This is a new record for Ceylon.

GALATHEIDEA.

FAMILY: PORCELLANIDÆ.

Petrolisthes militaris (HELLER). (See HENDERSON, 8.)

Localities:—(1) Cheval Paar and other pearl banks, Gulf of Manaar, shallow water; (2) off Galle, Station XXXVIII., 9 to 22 fathoms; (3) Palk Bay, Station XVIII., 7 to 8 fathoms; (4) Periya Paar, Station LV., 11 to 24 fathoms; (5) Muttuvaratu Paar, Station VI., 6 to 9 fathoms; (6) Chilaw Paar, Station III., 9 to 14 fathoms. This species was fairly abundant, the collection comprising about 25 specimens; carapace of largest measured 1·1 centims.

a little longer than broad, also crested internally, the crest being entire. Palm longer than the fingers. Fingers curved, slightly gaping, crossing at their tips and minutely notched on their opposing surfaces (see figure).

Walking legs short and slender, their last two joints bearing a few setæ.

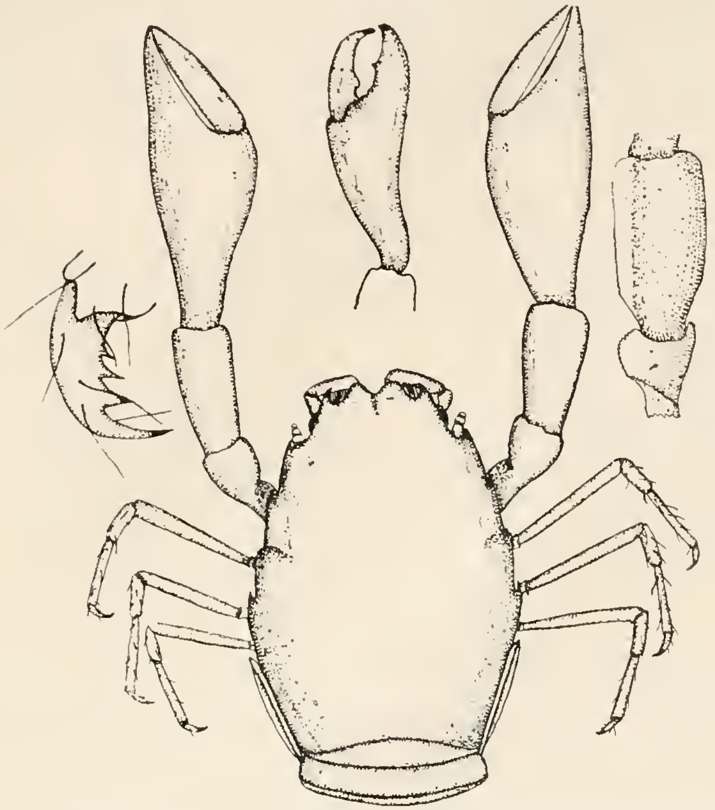

Fig. 1. *Porcellana hornelli*, n. sp., × 7; showing also right cheliped, × 6; merus and carpus of right cheliped, × 8; and dactylus of third left leg, × 30.

Localities:—(1) Aripu reef and other coral banks, Gulf of Manaar, shallow water; (2) Dutch Modragam Paar, Station LVII., 12 to 36 fathoms. Six specimens; length of carapace, 7 millims.; breadth, 6 millims.

This species is named in honour of Mr. James Hornell, F.L.S., who took an active part in making this collection.

Polyonyx biunguiculatus (Dana, 4).

Localities:—(1) Off Mutwal Island, Station LXVII., 10 to 14 fathoms; (2) coral banks, Gulf of Manaar, shallow water. Six males, and one female bearing eggs; length of carapace, 5 millims.

Dana figures the left cheliped of this species a little larger than the right one. Only one of the Ceylon specimens has both chelipeds intact, but in this case the right is very slightly larger than the left. Otherwise the specimens answer to

DANA's description and figure, and the tarsus of the walking legs is very noticeably two-clawed. This is a new record for Ceylon.

Polyonyx obesulus (WHITE). (See MIERS, 12.)

Locality:—Cheval Paar, Gulf of Manaar, shallow water. One specimen; carapace measuring 1 centim. This is a new record for Ceylon.

This and the last species seem so closely related that it is difficult to believe that they are distinct. Some of our Ceylon specimens seem intermediate in their characters.

Pachycheles pulchellus (HASWELL). (See MIERS, 12.)

Localities:—(1) Cheval Paar and other pearl banks, Gulf of Manaar, shallow water, nine specimens; (2) South of Modragam Paar, Station LXIV., 4 to 5 fathoms, one specimen.

Carapace of largest measured 9 millims. In these specimens the penultimate joints of the walking legs bear a few hairs on their external surface, and there is a little variation in the size of the crest on the carpus of the chelipedes.

This is a new record for the Indian Ocean, having only been found previously off the coasts of Australia.

FAMILY: GALATHEIDÆ.

Galathea elegans, WHITE. (See HASWELL, 6.)

Locality:—Chilaw Paar, 8 miles from shore, Station V., 9 to 11 fathoms. One specimen; extreme length 1·9 centims.

Galathea longirostris, DANA (4).

Localities:—(1) North of Cheval, Station LIII., 7 to 9 fathoms; (2) Gulf of Manaar, shallow water. Three specimens; extreme length 2 centims. Colour markings well defined. Brought up adhering to specimens of *Antedon bella*. This is a new record for the Indian Ocean.

Galathea corallicola, HASWELL (6).

Localities:—(1) South of Galle, Station XLI., 100 fathoms; (2) off Kaltura, Station XLIII., 22 fathoms; (3) coral reefs, Gulf of Manaar, shallow water. Six specimens in all; carapace of largest measuring 9 millims. This is a new record for the Indian Ocean.

Galathea australiensis, STIMPSON. (See HASWELL, 6.)

Localities:—(1) South of Galle, Station XLI., 100 fathoms; (2) off Kaltura, Station XLIII., 22 fathoms; (3) Gulf of Manaar, shallow water. In all, five males and two females bearing eggs; carapace of largest measured 1 centim.

In one of the specimens the rostrum was armed with only three teeth on the left side, the right side having four—the normal number. In STIMPSON'S original description of this species, from a female, it is stated that the fingers of the chelipeds did not gape. MIERS, describing a male of the same species (see **12**), specially noticed that the fingers in his specimen "had an hiatus between them when closed." In all the Ceylon specimens the fingers are gaping, some more than others; from which one may conclude that this character is of comparatively little importance. This is a new record for Ceylon. I am inclined to agree with MIERS that this and the last species might well be joined as one.

Galathea (?) grandirostris, STIMPSON. (See HENDERSON, **7**.)

Locality:—Dutch Modragam Paar, Station LVII., 12 to 36 fathoms. A damaged specimen, without chelipeds and legs, is doubtfully referred here. Rostrum long, deflexed, triangular, with a broad base, and armed laterally with small teeth; gastric region unarmed; striæ on the carapace numerous and ciliated; length of carapace, 1·6 centims. This is a new record for Ceylon.

Munida japonica, STIMPSON (**18**).

Localities:—(1) Trincomalee, Station XX., 11 to 13 fathoms; (2) south of Galle, Station XL., 34 fathoms; (3) off Kaltura, Station XLIII., 22 fathoms; (4) outside banks in Gulf of Manaar, Station LXIII., about 40 fathoms; (5) Aripu reef, shallow water. Thirteen specimens, including some females bearing eggs; the carapace of the largest measured 1·5 centims.

ORTMANN ('Zool. Jahr.,' Band 6, Abth. f. Syst., 1891–2, p. 254), in giving a detailed description of this species, pointed out that the abdomen was unarmed, and assumed that this was the case in STIMPSON'S original specimens, although STIMPSON himself did not describe the abdomen. ORTMANN also noticed that his types differed from those described by STIMPSON in having a large spine at the antero-lateral angle of the carapace.

The Ceylon specimens agree with ORTMANN'S description except in the following points:—

(1) The supra-ocular spines are as long as the eye.

(2) The setæ fringing the cornea are short.

(3) The spines in the transverse row on the anterior gastral region vary a little in number. Usually there are 13, consisting of 6 pairs and a median one. In one of the Ceylon specimens there are only 11 spines, the outer pair—normally situated near the edge of the carapace—being absent. In another specimen the median spine is short, blunt and rounded, with another spine behind it in the middle line.

(4) The lateral margin of the carapace is armed with 7 or 8 spines.

(5) The chelipeds vary enormously in length. In the female the fingers of the chelipeds are as long as the palm and scarcely gaping, whilst in the male the fingers

are shorter than the palm and the gape may be very pronounced, or scarcely noticeable.

(6) A few long iridescent hairs occur on the carapace and abdomen.

It might be thought that a variety could be established on these characters, but I prefer to regard them as individual variations. This species is new to the Indian Ocean, being only previously known from Japan.

Munida alcocki, n. sp.—Text-fig. 2.

The rostrum is about one-third the length of the carapace, and has about three regular and minute notches towards the apex. It is slightly sigmoid. The supra-orbital spines are as long as the eye and half the length of the rostrum. A few setæ

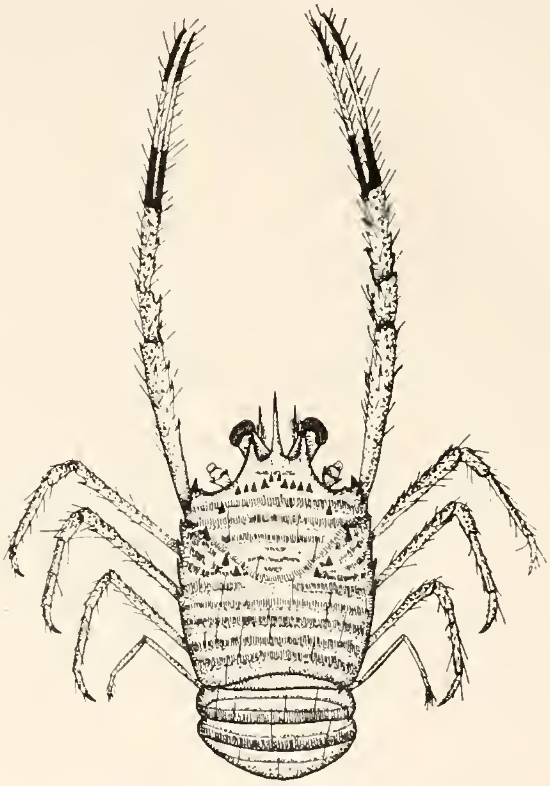

Fig. 2. *Munida alcocki*, n. sp., × 4.

overlap the cornea. The striæ on the surface of the carapace are numerous and pubescent. A few long iridescent hairs arise from the ridges of the thorax and abdomen. There is a transverse row of ten spines at the base of the rostrum. The median pair are situated a little in front of the rest, the second and fourth pairs being a little longer than the third and fifth. Separated from these by the first ciliated line is another pair of spines, situated laterally. Three additional pairs of lateral spines are situated a little behind the cervical groove, making eighteen spines in all. The lateral margin of the carapace is armed with seven spines.

The merus of the third maxilliped bears two large spines at the distal extremity.

The chelipeds are spinose and slender, nearly twice the length of the carapace, and bearing a few hairs. The spines on the merus increase in size distally. The fingers of the chelipeds are cylindrical, acute, slightly incurved, and in spirit specimens are marked with two red bands, one proximal, the other distal.

The walking legs bear a few hairs, and the tips of the anterior pair reach the base of the fingers of the chelipeds.

Localities:—(1) Dutch Modragam Paar, Station LVII., 12 to 36 fathoms; (2) Aripu Reef and elsewhere in Gulf of Manaar, shallow water; 23 specimens. The carapace of the largest individual measured 1·7 centims.

This species bears a general resemblance to *Munida honshuensis*, BENEDICT, in the disposition of the spines on the carapace, but differs from it in having (1) the abdomen unarmed; (2) the carapace a little broader; (3) the possession of long iridescent hairs; (4) the rostrum shorter; and (5) two additional spines on the carapace.

This species is named in honour of Col. ALCOCK, F.R.S., who has done so much to elucidate the Crustacean fauna of the Indian Ocean.

LITERATURE CITED.

(1.) ALCOCK.—'Catalogue of Indian Decapod Crustacea,' part ii., Anomura, fasc. i., Pagurides. Calcutta, 1905.

(2.) ALCOCK.—'Descriptive Catalogue of Indian Deep-sea Crustacea.' Calcutta, 1901.

(3.) BENEDICT.—'Proc. U.S. National Museum,' vol. xxvi., p. 243. 1902.

(4.) DANA.—'U.S. Explor. Expedition,' Crustacea, part i. 1852.

(5.) FAXON.—'Mem. Mus. Comp. Zool. Harvard,' xviii. 1895.

(6.) HASWELL.—'Catalogue of Australian Crustacea.' Sydney, 1882.

(7.) HENDERSON.—' "Challenger" Anomura.' 1888.

(8.) HENDERSON.—'Trans. Linn. Soc.' (2), vol. v., Zoology. 1893.

(9.) DE MAN.—'Journal Linn. Society,' Zool., vol. xxii. 1888.

(10.) MIERS.—"Revision of the Hippidea." 'Journal Linn. Society,' Zool., vol. xiv. 1879.

(11.) MIERS.—'Catalogue of New Zealand Crustacea.' London, 1876.

(12.) MIERS.—'Crustacea of H.M.S. "Alert."' Brit. Mus., London, 1884.

(13.) H. MILNE-EDWARDS.—'Histoire Naturelle des Crustacés.' Paris, 1837.

(14.) A. MILNE-EDWARDS and BOUVIER.—'Mem. Mus. Comp. Zool. Harvard,' vol. xiv., 3. 1893.

(15.) A. MILNE-EDWARDS and BOUVIER.—'Mem. Mus. Comp. Zool.,' vol. xix., No. 2. 1897.

(16.) A. MILNE-EDWARDS and BOUVIER, in Prince of Monaco's 'Résultats des Campagnes Scientifiques, fasc. vii., Anomures. 1894.

(17.) ORTMANN.—'Zoolog. Jahr.,' Bd. 6, Abth. f. Syst., 1891–2.

(18.) STIMPSON.—'Proc. Acad. Nat. Sci. Philad.' 1858.

REPORT

ON THE

FORAMINIFERA

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

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[WITH ONE PLATE AND TEXT-FIGURES.]

THE collection of deposits from the various places where dredgings were taken during the Ceylon expedition has revealed, in most cases, a great abundance of Foraminifera, and this is especially true with regard to a few species which in some cases make up the greater part of the deposit. The material which I have worked through for the purpose of this report had been taken mainly from (1) several stations in the Gulf of Manaar, (2) Palk Bay (north of Adam's Bridge), (3) off Trincomalee, and (4) off Galle, to the south of the island. The material from the different dredgings in the Gulf of Manaar has yielded the greatest abundance of species, and that from Galle and the south of the island generally the most interesting forms, especially where, from the 100-fathom line, about 12 miles off the land, the bottom was composed of a unique marine foraminiferal deposit, composed solely of a new species of the genus *Ramulina*. In the shallower waters off Galle, however, foraminifera were much less abundant than at corresponding depths in the Gulf of Manaar.

The deposits examined were mostly from depths of less than 40 fathoms, and the collection consists, therefore, mainly of shallow-water species, and there is but little difference between the various samples, except as regards the numerical proportions in which certain forms occur. One of the most interesting points is the great

abundance of *Heterostegina depressa*, which makes up as much as 40 per cent. of one deposit, and often attains a size of 18·5 millims., and *Amphistegina lessonii* is not far behind this in point of numbers. A considerable range of individual variation was noticed, especially as regards the surface markings in such a case as *Amphistegina lessonii*, and this has occasionally given rise to some difficulty in the determination of species.

The total number of species and varieties recorded is 131, belonging to 51 genera, and of these 49 species are recorded for the first time from the seas around India and Ceylon, most of the previous records being from the reports by MURRAY and CHAPMAN on the deposits obtained by H.M.S. "Investigator" in the Bay of Bengal and the Arabian Sea. Only 15 species have actually been recorded previously from Ceylon, consequently nearly all those mentioned in this report are additions to the fauna of that colony.

In conclusion, I have to thank Professor HERDMAN for the opportunity given me to examine this interesting collection, and also for his very valuable advice throughout the work.

NOTE ON A NEW RAMULINA DEPOSIT.

Along the 100-fathom line, about 12 miles south of Galle, the dredge brought up quantities of a remarkable and unique foraminiferal deposit, consisting of masses varying in size from a hazel nut to a small apple 5 centims. in diameter, and formed of many stout calcareous tubules. At first sight it would hardly oe taken to be of Protozoan origin; and, as a matter of fact, a few other animals occur with it. Worm tubes extend into the crevices and wind about the tubules: masses of *Polytrema* and colonies of Polyzoa use the foraminifer as a support, and corals are embedded by its vigorous growth. The result is a substantial marine deposit, which cannot be of small importance in the building up of the ocean floor, and is still another, and probably the most important case in the district, of the part played by foraminifera in contributing to the form of the earth's surface, and in affecting the metabolism of the ocean. This organism has been identified as a very luxuriant and complex growth of a new species of *Ramulina*, which I desire to name after Professor HERDMAN, by whom it was found and first identified as a *Ramulina* (see "Narrative," this Report, Part I., 1903, p. 51).

The genus *Ramulina* of RUPERT JONES, 1875, is defined by BRADY in the '"Challenger" Report' as follows:—"Test free, branching; consisting of a calcareous tube, swollen at intervals so as to form more or less definite, often irregular segments, from which lateral stolons or branches are given off. Texture hyaline." Some alteration will, however, have to be made in this definition of the genus, since this new species is certainly not hyaline. The species described by BRADY is *R. globulifera*, and from the description it appears that the swellings referred to in the definition of the genus arise only at intervals, and are connected by tubular portions. In our

Ceylon species, on the other hand, there may be a whole series of globular segments opening directly one into the other.

The generic name was first applied in the 'Report and Proc. Belfast Nat. Field Club,' 1873, by JOSEPH WRIGHT, to two fragmentary specimens, and no definitions were then given. Later, the name was definitely given to the genus by RUPERT JONES, in 1875. BRADY, in 1884, named and described the species *R. globulifera*, and WRIGHT, also in 1884, figured another species, *Ramulina aculeata*, from specimens found in the cretaceous rocks of Kerry, Ireland. Mr. WRIGHT, who was consulted by Professor HERDMAN, at first recognised the resemblance of this species from Ceylon to his *R. aculeata*; but further investigation suggested that it is a new species, and with that opinion Mr. WRIGHT now concurs.

The differences leading to this conclusion are that (1) the spinous processes are not developed to such an extent on the Ceylon species as on *R. aculeata*, and (2) the cretaceous species only occurs in small fragments and does not show the complex and extensive mode of growth seen in this specimen from the Indian Ocean.

This foraminifer consists of a mass of anastomosing calcareous tubes, inextricably commingled, and assuming two principal forms of growth. Many specimens show a long series of globular segments, arranged irregularly, and opening directly into one another by large openings. These globular chambers at intervals give off numerous radiating straight tubes, varying in length from quite small outgrowths to 1·25 centims., with a diameter of 1·5 millims. to 2 millims. These straight portions may run in the same direction, separating but little, and becoming more compact (see text-fig., C), or they may at once diverge and radiate from a common centre.

A. B. C.

Three masses of *Ramulina herdmani*. Natural size.

Eventually they reach either the globular chambers or other straight tubules with which they fuse, the cavities becoming continuous (see also Plate, figs. 1–6).

The radiating straight tubes I shall term the *pipes*, and the globular chambers

ampullæ. These masses of *Ramulina herdmani* may be in places predominantly ampullate in their mode of growth, as in text-fig. C, which shows an irregular mass of ampullæ opening into one another at different angles, and not lying simply in one and the same plane. In fig. A, on the other hand, the ampullæ are arranged in definite planes (not parallel to one another), and between these planes pass the pipes opening into the ampullæ at either end. The larger piece, shown in fig. B, is almost wholly composed of pipes, with only a suggestion of ampullæ, or perhaps two or three where several pipes open near each other.

The walls of the pipes and ampullæ are strong, calcareous, but not hyaline, and in some places as much as 0·065 millim. in thickness; but about 0·05 millim. is the average. All these walls are uniformly perforate, but the external surface differs in appearance in places, being sometimes quite smooth and elsewhere bearing minute denticles, either sparsely or more closely set. There also seem to be definite larger openings to the exterior, or *mouths* (see Plate, fig. 5). These are quite large openings, about 2·5 millims. across, and are situated where one or two ampullæ meet. They do not occur very frequently.

At such mouths the walls of the ampullæ are prolonged to form 4 to 6 protuberances of unequal size which surround the orifice.

In accordance with this description of the new species, the definition of the genus requires to be somewhat modified—which, however, was necessary before, since the original definition will not include WRIGHT'S *Ramulina aculeata.*

The definition of the genus given by BRADY was quoted above. I should suggest that this be now modified so as to read:—Test free, *or adherent,* branching and *anastomosing;* consisting of a calcareous tube, swollen at intervals to form more or less definite, often irregular segments (*ampullæ*), *opening into one another and being contiguous, or separated and connected by tubules. From these segments straight tubes* (*pipes*) *are given off.* Texture hyaline *or opaque.*

The alterations or additions are printed in italics. The definition of the new species will be given at its systematic position in the catalogue that follows.

LIST OF SPECIES.

FAMILY: MILIOLIDÆ.

Biloculina ringens (LAMARCK).

This form occurs rarely in the deposit from Stat.* LXVIII. It has been recorded (2),† (4) from the Indian seas.

Biloculina ringens, var. **striolata,** BRADY.

Of very rare occurrence in material from Stat. LXIV., south of Modragam Paar, depth 5 fathoms. This variety has also been recorded from the Indian seas (2).

* For particulars as to the Stations see "Narrative," this Report, Part I., 1903, p. 17.

† These numbers refer to the bibliography at the end.

Biloculina ringens, var. denticulata, Brady.

Of very rare occurrence in material from Stat. LVIII., Gulf of Manaar—a new record for Indian seas.

Biloculina lævis (Defr.).

Of rare occurrence in the Gulf of Manaar. This is a new record for Indian seas.

Miliolina cultrata, Brady.

Occurs frequently at Stats. LVI. to LVIII., near Karativo Paar, 8 to 26 fathoms. Previously recorded by Brady (1) from Ceylon.

Miliolina seminulum (Linn.).

This is common at the same stations as the last, and also off Trincomalee—a new record for Indian seas.

Miliolina scrobiculata, Brady.

This form appears rarely in the sample from Stat. LVII. It is a new record for Indian seas.

Miliolina tricarinata (d'Orb.).

Occurs very rarely at Stats. LVI., LVII. and LXVIII. It has been recorded (2) from Indian seas.

Miliolina auberiana (d'Orb.).

Found in samples from Stats. LVI., LVII. and LVIII., and also from Welligam Bay—previously recorded (2) from Indian seas.

Miliolina insignis, Brady.

This form occurs in material from Stats. LVII. and LXIV.—previously recorded from Ceylon (1) and Indian seas (2).

Miliolina valvularis (Reuss).

Occurs in material from Stat. LVIII., outside Karativo Paar, depth about 20 fathoms. This is a new record for Indian seas.

Miliolina ferussacii (d'Orb.).

Occurs very rarely in the same sample as the last, and is also a new record for Indian seas.

Miliolina circularis, Bornemann.

This form was also present in the material from Stat. LVIII.—recorded previously from Indian seas (2).

Miliolina fichteliana (D'ORB).

Present sparingly at Stat. LVIII., and also at Stat. LVI., off Kodramallai Point, depth 8 or 9 fathoms—a new record for Indian seas.

Miliolina parkeri, BRADY.

Found at Stat. LVIII. This form is usually found associated with coral banks—recorded previously from Indian seas (2).

Miliolina rupertiana, BRADY.

Occurs frequently in material from Stat. LVI.—previously recorded for Ceylon (1).

Miliolina oblonga (MONTAGU).

This form occurs rarely in two samples from the Gulf of Manaar, Stats. LXIV. and LXVIII., both under 20 fathoms; and also at Welligam Bay—previously recorded from Ceylon (1).

Miliolina agglutinans (D'ORB.).

Very rare, and occurs only at Stat. LXIV. This is a new record for Indian seas.

Miliolina reticulata (D'ORB.).

Occurs sparingly between E. and W. Cheval paars at about 6 to 7 fathoms—previously recorded from Indian seas (2).

Miliolina terquemiana, BRADY—Plate, figs. 9 and 10.

This species, described by BRADY for the first time in the '"Challenger" Report' (1), is noted as being exceedingly rare, and known only from Calpentyn, Ceylon, and the East Coast of Madagascar. It has been recorded so far from no other place in the Indian Ocean. One specimen only was present in our collection, and it was found in a deposit from the southern part of the Gulf of Manaar, only a few miles to the north of Calpentyn, where it was originally found. It is in excellent preservation and is rather larger than BRADY's specimen, the length being 0·76 millim. This rare Ceylon specimen is shown in figs. 9 and 10 on the Plate.

Spiroloculina grata, TERQUEM.

This is common in deposits from Stats. LVI and LXIV. It is a coral bank species, and has been previously recorded from Indian seas (2).

Spiroloculina limbata, D'ORB.

Frequent in deposits from Stats. LVIII. and LVI.—previously recorded from Indian seas (2).

Spiroloculina fragilissima, BRADY.

One specimen in material from Stat. LVIII.—a new record for Indian seas.

Spiroloculina arenaria, Brady.

This species occurs in material from Stat. LVIII.—previously recorded from Indian seas (2).

Spiroloculina crenata, Karrer.

Of very rare occurrence in the deposit from Stat. LVI.—a new record for Indian seas.

Hauerina ornatissima, Karrer.

Very rare in material from Stat. LXIV., S. of Kodramallai. This is a new record for Indian seas.

Hauerina complanata, n. sp.—Plate, fig. 7.

This species has the characteristic planospiral porcellaneous test, milioline only in the very early convolutions. It is very thin, with practically circular convolutions. Four of these, with indications of a fifth, are present; the outer, or last, consisting of four chambers. Diameter of specimen, 0·62 millim. This species differs from *H. compressa* in being more regular and even more compressed; the number of convolutions also appears to be greater and a larger number of chambers is present. Several specimens occur in deposits from Stat. LVIII., Gulf of Manaar.

Articulina sagra, d'Orb.

Occurs frequently in deposits from Stats. LXVIII., LXIV. and LVII. This is a new record for Indian seas.

Vertebralina striata, d'Orb.

Occurs rarely in the Gulf of Manaar—a new record for Indian seas.

Peneroplis pertusus, var. **arietinus**, Batsch.

This occurs very commonly in the deposit from Stat. LVII., and less frequently at Stat. LVI.

Peneroplis pertusus, var. **planatus** (Fichtel and Moll).

This variety is much less common than the above, and occurs rarely at Stat. LVII. These are both new records for Indian seas.

Orbiculina adunca (Fichtel and Moll).

This species is of somewhat rare occurrence in the Gulf of Manaar—previously recorded for the Indian Ocean (1).

Orbitolites marginalis (Lamk.).

One of the most common of foraminifera in the shallower deposits, but less frequent

in the deeper ones. It is common, however, in all. Previously recorded from the Indian Ocean (2).

Orbitolites duplex, Carpenter.

Occurs rarely at Stat. LVII—a new record for Indian seas.

Alveolina melo (Fichtel and Moll).

This is exceptionally common in the shallow-water deposits, and makes up a large percentage of the material. In most cases also the size is above the average, the length reached being 22·5 millims. It occurs at Stats. LXIV., LVI., LVIII. ; off Trincomalee and Chilaw ; but is especially common in the deposit from Stat. LXVIII.

Alveolina boscii (Defr.).

This is frequent in the same deposits as the species *A. melo.* Both have been previously recorded from the Indian Ocean (2).

Family : ASTRORHIZIDÆ.

Technitella legumen, Norman.

Of very rare occurrence from the Gulf of Manaar—a new record for the Indian seas.

Saccammina spherica, Sars.

Of rare occurrence at Stats. LVI. and LVIII.—previously recorded from Indian seas (2).

Rhizammina, sp. ?

One specimen from Gulf of Manaar. The species *R. indivisa* has been previously recorded from Indian seas (2).

Sagenella frondescens, Brady.

Of rare occurrence in deposits off Chilaw. This is a new record for Indian seas.

Family : LITUOLIDÆ.

Reophax difflugiformis, Brady.

Occurs somewhat frequently in Gulf of Manaar—previously recorded from Indian seas (2).

Haplophragmium canariense (d'Orb.).

Only one specimen in material from Stat. LVIII.—previously recorded from Indian seas (2).

Carterina spiculotesta (CARTER).

One specimen was found in the deposit from Stat. LXIV. in Gulf of Manaar. This is of interest since the specimens described by CARTER came from the same place (1).

FAMILY: TEXTULARIIDÆ.

Textularia gramen, D'ORB.

Occurs in deposits from Stats. LVIII., LVII., LXIV., and LXVIII.—previously recorded from Indian seas (2).

Textularia agglutinans, D'ORB.

Of frequent occurrence at Stats. LVIII., LVII., and LVI.—previously recorded from Indian seas (2).

Textularia transversaria, BRADY.

Occurs rarely at Stat. LVIII. A new record for Indian seas.

Textularia quadrilatera, SCHWAGER.

Occurs rarely at Stat. LVII. This also is a new record for Indian seas.

Textularia sagittula, DEFRANCE.

Occurs rarely in the Gulf of Manaar, at Stat. LVI.—previously recorded from Indian seas (2).

Textularia sagittula, var. **fistulosa**, BRADY.

This variety is of more frequent occurrence than the above, and is probably a tropical variation of it. It was found in the Gulf of Manaar—previously recorded from Indian seas (2).

Verneuilina spinulosa, REUSS.

Occurs rarely at Stats. LVII. and LVI. in Gulf of Manaar—previously recorded from Ceylon (1).

Chrysalidina dimorpha, BRADY.

Found sparingly at Stat. LVIII.—recorded previously from Ceylon (1).

Clavulina communis, D'ORB.

Very rare at Stat. LVIII. Has been previously recorded from Indian seas (2).

Gaudryina subrotundata, SCHWAGER.

This is of moderate frequency in several deposits in the Gulf of Manaar—previously recorded from Indian seas (2).

Bulimina elegantissima, var. **seminuda**, Terquem.

This form is of rare occurrence at Stat. LVIII.—has been previously recorded from Ceylon (1).

Bolivina punctata, d'Orb.

This is of fairly frequent occurrence at Stats. LVI. and LXIV. It has been already recorded from Indian seas (1), (2).

Bolivina textularioides, Reuss.

Of rare occurrence in the Gulf of Manaar—previously recorded from Indian seas (2).

Bolivina limbata, Brady.

Of rare occurrence in the deposit from Trincomalee, W.N.W. of Foul Point, 8 fathoms—previously recorded from Indian seas (2).

Family: LAGENIDÆ.

Lagena sulcata (Walker and Jacob).

Of very rare occurrence at Stat. LVI.—recorded previously from Indian seas (2).

Lagena globosa (Montagu).

Rare in deposit from Stat. LVI.—recorded previously from Indian seas (2).

Lagena lævis (Montagu).

Of very rare occurrence in deposit from Stat. LXIV., and also from Welligam—recorded previously from Indian seas (2).

Lagena lagenoides (Williamson).

This is of very rare occurrence in the deposit from Stat. LXVIII.—recorded previously from Indian seas (2).

Lagena castrensis, Schwager.

This form is very rare in the deposit from Stat. LVIII., and also from Welligam Bay—recorded previously from Indian seas (2).

Lagena orbignyana (Seguenza).

This form is also very rare in the Gulf of Manaar.

Lagena staphyllearia (Schwager).

Of very rare occurrence in the Gulf of Manaar.

Lagena marginata, var. **semimarginata**, Reuss.

Of very rare occurrence in the Gulf of Manaar deposits. The last three species of *Lagena* have all been previously recorded from the Indian seas (2).

Lagena elcockiana, Millet (3).

Only one specimen found in a deposit from the Gulf of Manaar. This is a new record for Indian seas. Previous occurrence in the Malay Archipelago (3).

Nodosaria obliqua (Linn.).

This species occurs sparingly at Stat. LVIII., but is more frequent at Stat. LVI., both in the Gulf of Manaar. Recorded previously from Indian seas (2).

Nodosaria cylindracea, n. sp.—Plate, fig. 8.

The test of this species is elongate, and cylindrical, 0·85 millim. in length, and terminates in a rounded apex. Chambers, about nine in number, arranged in a straight line, and separated by unconstricted sutures, which have the appearance of a series of depressions. Surface with fine longitudinal ribs, about eighteen in number, and marked with minute striæ between them. Aperture, a round opening with a slight lip in the centre of the last segment.

It is possible that this is a new species of the genus *Sagrina*, in which the early spiral arrangement has been lost, but no trace of this is seen in the specimen.

Of very rare occurrence in the Gulf of Manaar.

Nodosaria raphanus (Linn.).

This form occurs somewhat frequently in the Gulf of Manaar. Recorded previously for Indian seas (2).

Nodosaria intercellularis, Brady.

Occurs sparingly at Stats. LVIII., LVII., and LVI. This is also previously recorded from Indian seas (2).

Nodosaria perversa, Schwager.

Of rare occurrence in the Gulf of Manaar—a new record for Indian seas.

Nodosaria simplex, Silv.

Of very rare occurrence in Gulf of Manaar at Stat. LXIV.—a new record for Indian seas.

Nodosaria hispida, d'Orb.

This species is of rare occurrence in the Gulf of Manaar. This is also a new record for Indian seas.

Nodosaria scalaris, var, **separans**, Brady.

Rare in the deposit from Stat. LXIV. This has been recorded from the Indian seas already (2).

Cristellaria tricarinella, REUSS.

Of very rare occurrence in the deposit from Stats. LVIII. and LVI. This is a new record for the Indian seas.

Cristellaria rotulata (LAMK.).

This is of rare occurrence in the Gulf of Manaar—previously recorded from Indian seas (2).

Cristellaria orbicularis (D'ORB.).

Occurs very rarely in the samples from Stat. LVI.—previously recorded from Indian seas (2).

Cristellaria vortex (FICHTEL and MOLL).

This is of rare occurrence in the deposit at Stat. LXIV. This is a new record for Indian seas.

Polymorphina regina, BRADY, PARKER and JONES.

Occurs very rarely in material from Stat. LXIV.—a new record for Indian seas.

Uvigerina aculeata, D'ORB.

This is of frequent occurrence at Stat. LXIV. in some hauls—previously recorded from Indian seas (2).

Uvigerina asperula, CZJZEK.

Of rare occurrence at Stat. LVIII. This species is previously recorded from Indian seas (2).

Uvigerina pygmæa, D'ORB.

Found sparingly at Stat. LVII., and also at Welligam Bay. Also recorded before from Indian seas (2).

Sagrina raphanus, PARKER and JONES—Plate, fig. 11.

Found sparingly at Stat. LVI., and also off Trincomalee—previously recorded for Ceylon (1). The specimen figured differs from the normal type by having the test bent almost at right angles in the fifth chamber from the terminal one. This appears due to greater growth having taken place on one side than on the other during the formation of this chamber.

Sagrina striata, SCHWAGER.

Of rare occurrence in the Gulf of Manaar—a new record for Indian seas.

Ramulina herdmani, n. sp.—Plate, figs. 1–6, and also text-figs., p. 227.

Tubules anastomosing so as to form a large adherent mass. Chambers or ampullæ

numerous, connected by tubules or contiguous and aggregated. Walls strong, calcareous, not hyaline, and only slightly spinose on the surface. Length of an average pipe 1 centim., diameter of an average ampulla 1·8 millims., masses up to 9 centims. in length. (See also p. 226.)

Family: GLOBIGERINIDÆ.

Globigerina bulloides, d'Orb.

This is a common form in all the deposits examined—previously recorded from Indian seas (2) (4).

Globigerina sacculifera, Brady.

Of very rare occurrence at Stat. LVI.—previously recorded from Indian seas (2) (4).

Globigerina cretacea, d'Orb.

Of very rare occurrence at Stats. LXVIII. and LVI.—previously recorded from Indian seas (2).

Orbulina universa, d'Orb.

Rare, found in material from Stat. LVI.

Hastigerina pelagica, d'Orb.

Of very rare occurrence at Stat. LVII. Both the two last named have been previously recorded from Indian seas (2) and (4).

Family: ROTALIIDÆ.

Spirillina limbata, Brady.

Common in deposits from Stat. LVII.—a new record for Indian seas.

Spirillina obconica, Brady.

Of rare occurrence from Galle and Station LXIV.—a new record for Indian seas.

Spirillina inæqualis, Brady.

Of rare occurrence at Galle and Stat. LVI.

Spirillina vivipara, Ehrenberg.

This occurs rarely in deposits from Stats. LVIII. and LVII.—previously recorded from Indian seas (1).

Spirillina decorata, Brady.

Of very rare occurrence at Stat. LVI. With the exception of *S. vivipara*, these are all new to Indian seas. They have all been recorded by Egger (5) from Mauritius.

Cymbalopora poeyi (d'Orb.).

Occurs rarely at Stat. LVI., and also off Trincomalee—previously recorded from Indian seas (2).

Discorbina rosacea (d'Orb.).

Occurs frequently at Stats. LVIII. and LXIV. This has been recorded from Indian seas (2).

Discorbina orbicularis (Terquem).

Of common occurrence at Stats. LVII., LXIV., and LXVIII., in the Gulf of Manaar. This is a new record for Indian seas.

Discorbina bertheloti, var. **baconica**, Hantk.

Found sparingly in deposits from Stats. LVII. and LVI., and, like the last, is a new record for Indian seas.

Discorbina patelliformis, Brady.

Found rarely in the Gulf of Manaar. It has been already recorded from Ceylon (1).

Discorbina saulcii (d'Orb.).

Occurs rarely in the Gulf of Manaar—a new record for Indian seas.

Discorbina vilardeboana (d'Orb.).

This occurs very rarely in the Gulf of Manaar, and is probably a variety of *D. rosacea*. It is a new record for Indian seas.

Truncatulina ungeriana (d'Orb.).

Of rare occurrence in the deposits from the Gulf of Manaar—previously recorded from Indian seas (2).

Truncatulina rostrata, Brady.

Occurs rarely in deposits from Stat. LVIII. in the Gulf of Manaar—a new record for Indian seas.

Truncatulina lobatula (Walter and Jacob).

This species is very rare in the deposit from Stat. LXVIII.—already recorded from the Indian seas (2).

Truncatulina tenera, Brady.

This species occurs somewhat frequently in the Gulf of Manaar. It is also a new record for Indian seas.

Anomalina ammonoides (Reuss).

Occurs frequently in deposits from Stats. LVII. and LVIII.—previously recorded from Bombay (1).

Anomalina gosserugosa (Gümbel).

This species is much more rare than *A. ammonoides*, but occurs in the same deposits—previously recorded from Indian seas (2).

Anomalina ariminensis (d'Orb.).

Of very rare occurrence at Stat. LVI.—a new record for Indian seas.

Pulvinulina menardii (d'Orb.).

Very common at Stats. LVI., LVII., LVIII., LXIV. and LXVIII.—previously recorded from Indian seas (2), (4).

Pulvinulina brongniarti (d'Orb.) (4).

This species occurs rarely in the deposit from Stat. LVII.—previously recorded from Mauritius (5) and Malay Archipelago (3)—a new record for Indian seas.

Pulvinulina umbonata, Reuss.

Occurs rarely in material from Stat. LVIII. This is a new record for Indian seas—previously recorded from Mauritius (5).

Pulvinulina oblonga (Williamson).

Of rare occurrence at Stats. LXVIII. and LVI.—previously recorded from Indian seas (2).

Rotalia calcar, d'Orb.

This species is of very common occurrence at Stats. LVI., LVII., LVIII., and also from Welligam Bay and Galle—recorded already from Ceylon (1) and Indian seas (2).

Calcarina hispida, Brady.

Of very common occurrence in all samples examined from Stats. LVIII., LVII., LVI., LXIV., and LXVIII., also off Galle and Trincomalee—previously recorded from Indian seas (2).

Calcarina defrancii, d'Orb.

This occurs somewhat sparingly at Stats. LVI. and LVIII.—a new record for Indian seas.

Calcarina spengleri, Linn.

Of rare occurrence at Stat. LVIII. This is also a new record for Indian seas, but has been recorded from Mauritius (5).

Planorbulina larvata, PARKER and JONES.

Occurs sparingly at Stats. LXIV. and LVII. It has been recorded from Indian seas previously (**2**).

Planorbulina mediterranensis, D'ORB.

This is of rare occurrence at Stats. LXVIII. and LVIII.—a new record for Indian seas; recorded previously from Mauritius (**5**).

Gypsina inhaerens (SCHULTZE).

Occurs rarely at Stat. LVII. This is a new record for Indian seas; recorded from islands south of New Guinea and from the European coast (**1**).

Carpenteria utricularis, CARTER.

Occurs on calcareous Algæ from the Gulf of Manaar and also off Galle. Recorded previously from the Gulf of Manaar (**7**).

Polytrema miniaceum, LINN.—Plate, fig. 12.

Of very frequent occurrence, and forming at Stat. LXVIII. quite a large proportion of the foraminifera. Also found at Stats. LVI., LVII., LVIII., and LXIV. A fine specimen is figured. Recorded previously from Ceylon (CARTER, **7**).

Polytrema miniaceum, var. **alba,** CARTER.

Of rare occurrence in deposits from Stat. LVIII.—recorded previously from Gulf of Manaar by CARTER.

FAMILY: NUMMULINIDÆ.

Nonionina boueana, D'ORB.

Of very rare occurrence, from stations in the Gulf of Manaar. This is the first record for Indian seas; previously recorded from the Red Sea (**1**) and Mauritius (**5**).

Polystomella crispa (LINN.).

Very common in all the deposits examined from Stats. LVIII., LVI., LVII., LXIV. and LXVIII., also from Trincomalee, Welligam Bay and Galle—previously recorded from Indian seas (**2**).

Polystomella craticulata (FICHTEL and MOLL).

Of very rare occurrence at Stat. LVII. This is the first record for Indian seas; recorded already from Mauritius (**5**) and Red Sea (**1**).

Amphistegina lessonii, D'ORB.—Plate, fig. 13.

This is extremely abundant in all the deposits, and forms about 25 per cent. by weight and volume of the deposit from a haul at Stat. LXIV. Its surface

markings are extremely variable ; one of the varieties is figured and this specimen was not in any way water worn. Noted from Stats. LVI., LVII., LVIII., LXVIII., and other hauls at Stat. LXIV., also off Galle, Trincomalee and Chilaw. Recorded from the Indian seas previously (2).

Amphistegina radiata (FICHTEL and MOLL).

Rather rare, from Gulf of Manaar. Recorded by CHAPMAN (2) from Arabian seas.

Heterostegina depressa, D'ORB.—Plate, fig. 14.

This is the most abundant foraminifer at practically all the stations. Its size is on the whole above the average, often attaining a diameter of 18·5 millims., and it gives therefore the chief character to the deposit. On these grounds a figure is given here (fig. 14) from one of the most perfect specimens. Occurs at Stats. LVI., LVII., LVIII., LXIV., LXVIII., and off Galle, Trincomalee and Chilaw. Previously recorded from Ceylon (1) and Indian seas (2).

Operculina complanata (DEFR.).

Occurs sparingly at Stats. LVII. and LXIV.—previously recorded from Indian seas (2).

Operculina complanata, var. granulosa, LEYMERIE.

This variety occurs somewhat frequently in the Gulf of Manaar. Like the previous species, it has been already recorded from Indian seas (2).

LIST OF WORKS REFERRED TO.

(1.) BRADY.—Report on the Foraminifera collected by H.M.S. "Challenger."

(2.) CHAPMAN.—"Foraminifera obtained by H.M.S. 'Investigator' near the Laccadive Islands." 'Proc. Zool. Soc.,' 1895, pt. i.

(3.) MILLET.—"Foraminifera of the Malay Archip." 'Journ. Microscop. Soc.' 1889-1902.

(4.) MURRAY.—"List of Forams. collected in Bay of Bengal." 'Scottish Geographical Mag.' 1889.

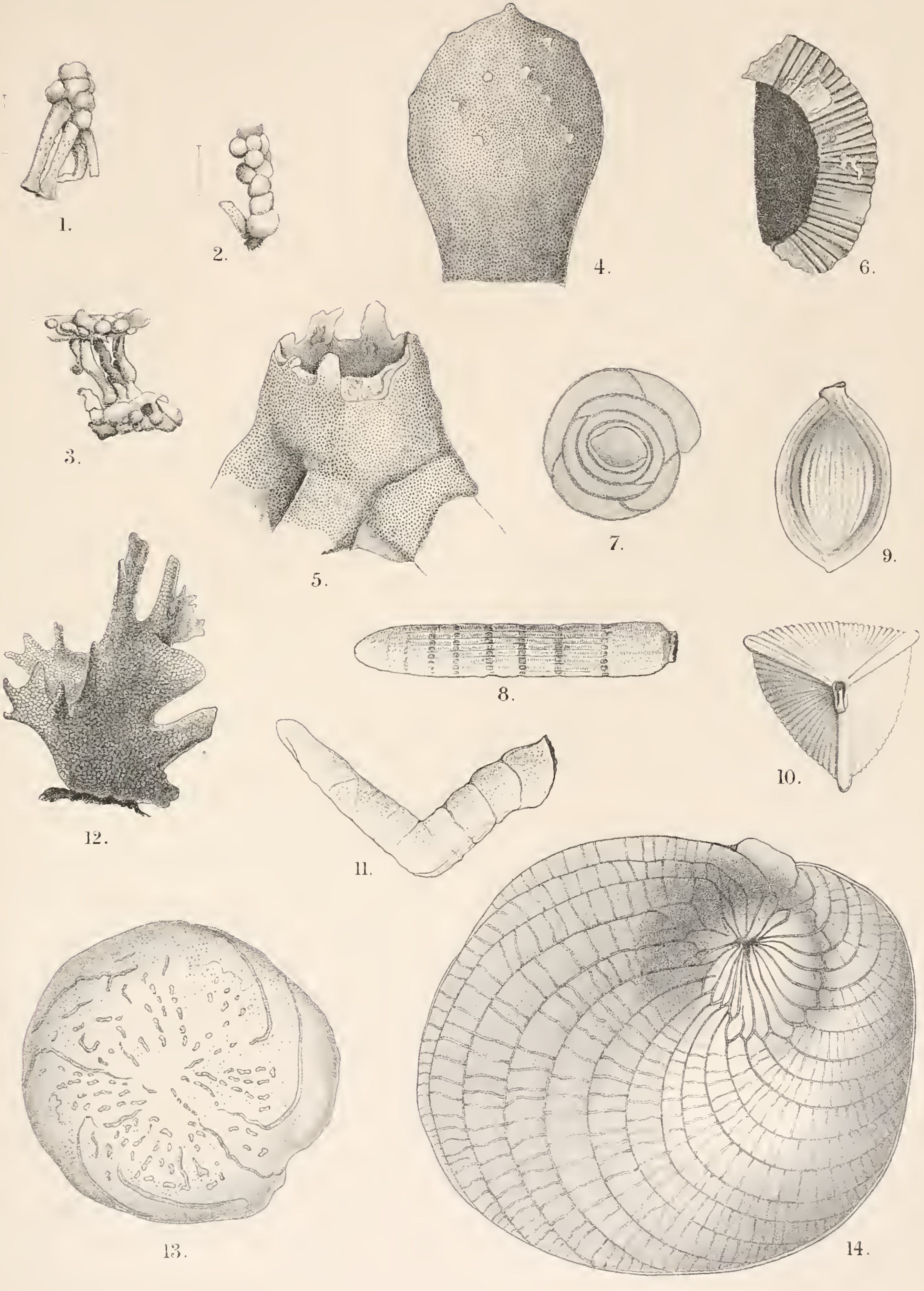
(5.) EGGER—'Abhandl. k. Bayer. Akad. Wiss. München.' 1893.

(6.) FLINT.—"Recent Foraminifera." 'Report U.S. Nat. Mus. for 1897.'

(7.) CARTER.—'Ann. and Mag. Nat. Hist.' June and July, 1880.

EXPLANATION OF THE PLATE.

Fig. 1. Specimen of *Ramulina herdmani*, n. sp., showing relation of ampullæ to pipes. × 2.
,, 2. Another specimen, showing a series of ampullæ. × 2.
,, 3. Specimen to show ampullæ in two planes connected by pipes. × $\frac{3}{2}$.
,, 4. An ampulla, to show surface. × 19.
,, 5. "Mouth" on an ampulla, showing processes. × 16.
,, 6. Section showing wall of an ampulla. × 22.
,, 7. *Hauerina complanata*, n. sp. × 48.
,, 8. *Nodosaria cylindracea*, n. sp. × 73.
,, 9. *Miliolina terquemiana*, BRADY. × 47.
,, 10. The same, oral view. × 47.
,, 11. *Sagrina raphanus*, PARKER and JONES, abnormal. × 58.
,, 12. *Polytrema miniaceum*, LINN., large specimen. × 8.
,, 13. *Amphistegina lessonii*, D'ORB. × 20.
,, 14. *Heterostegina depressa*, D'ORB. × 23.



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REPORT

ON

JOUSSEAUMIA

A NEW GENUS OF EULAMELLIBRANCHS COMMENSAL WITH THE CORALS HETEROCYATHUS AND HETEROPSAMMIA

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

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[WITH THREE PLATES.]

IN a very interesting paper describing the true nature of the commensalism between corals of the genera *Heteropsammia* and *Heterocyathus* and a Sipunculid belonging to the genus *Aspidosiphon*, E. L. BOUVIER (4) pointed out that there is a third partner in the commensalism in the form of a minute Lamellibranch which he figured and named *Kellia deshayesi*, without, however, giving any diagnosis of the species. As I shall point out in the course of this report, BOUVIER'S figure, though it gives a correct enough representation of the external form of the Mollusc, as seen lying in the left valve of its shell, is incorrect in the representation of the hinge teeth, and the Lamellibranch in question certainly does not belong to the genus *Kellia*, differing from it not only in the hinge teeth, but also in the sutural unions of the mantle edges and in other important particulars. Though BOUVIER announced that his colleague M. JOUSSEAUME intended to make a study of this commensal Lamellibranch, it does not appear to have been described or to have attracted any further notice until Dr. A. E. SHIPLEY in his report on the Gephyrea collected by Professor HERDMAN in Ceylon (13) mentioned its occurrence along with *Aspidosiphon* in the basal

chambers of *Heteropsammia* and *Heterocyathus*, and states that it was referred by Mr. E. A. Smith to Angas' genus *Mysella*.

Among the solitary corals from Ceylon sent me by Professor Herdman were numerous spirit-preserved specimens of *Heteropsammia michelini* and *Heterocyathus æquicostatus*, and on opening the *Aspidosiphon* chamber in one of these I was at once struck by the presence of the numerous small Lamellibranchs, many of them imbedded in the skin of the posterior part of the body of the Sipunculid, as described by Bouvier; others lying free in the innermost coils of the chamber, especially in its terminal part.

Having many specimens of the corals at my disposal, I examined a large number of them and invariably found a number of the Lamellibranchs inhabiting the *Aspidosiphon* chamber. In some of the larger specimens of *Heteropsammia* I found as many as 30 or 35 specimens of different ages, in some of the smaller specimens of *Heterocyathus* not more than a dozen or fifteen.

Bouvier left it an open question whether the commensal Mollusc was an adult form or not. My observations quickly showed me that a proportion of the specimens inhabiting each coral were adult, and that along with them were numerous young forms in all stages of growth. With the abundant material at my disposal I proceeded to make a careful study of the anatomy, and, as far as the circumstances allowed, the development of this hitherto undescribed species, and although but few out of the many specimens were sufficiently well preserved to admit of satisfactory microscopical examination, I found a sufficient number in good enough condition to enable me to work out the structure in some detail.

DESCRIPTION OF THE GENUS AND SPECIES.

The description of the genus *Mysella* given by Angas (1) is based on the characters of the shell only, and his figure of the hinge apparatus is so small that it is difficult to make out the characters of the hinge teeth clearly, but it is evident that the species commensal in the two corals cannot be referred to his genus.

The specimen on which the genus *Mysella* was founded was 7·5 millims. in length, and was found in black mud near Port Jackson. The shell is inequilateral, the anterior side being the shorter and subtruncate; judging by the figure, the umbones are prosogyrous. The ligament is internal, and there is a single small diverging subcircular flattened cardinal tooth in one valve, and two short thin horizontal lateral processes in the other valve.

My specimens agree with *Mysella* in having an internal ligament, and in having a single cardinal tooth in the right valve and two teeth in the left valve; but there are in addition well-developed lateral teeth, and the shape of the shell is quite different. Moreover, the largest of my specimens does not exceed 1·5 millims. in length and the average length of the adult forms is 1·0 millim.

It is extremely difficult to get a clear view of the hinge teeth in very small bivalve shells. Bernard (3) has remarked on the unsatisfactory results obtained from dry specimens mounted on black paper and recommends fixing them direct on a glass slide and varying the sub-stage illumination. I found that much the most satisfactory results were obtained by thoroughly cleaning the shells in potash or Eau de Javelle and then mounting them under a coverslip in glycerine jelly. By altering the sub-stage illumination and rotating the stage one can get very clear pictures of the minutest details.

After a careful examination of the shells and of the anatomy of my specimens, I satisfied myself that they belonged to two species of a new genus, which I propose to call *Jousseaumia*, in honour of the French naturalist who first discovered this Mollusc in the *Aspidosiphon* chamber of the two above-named corals. This new genus and the two species may be defined as follows :—

Jousseaumia, n. gen.

Shell small, thin, triangular, equivalve, inequilateral, the anterior side the longer, with numerous fine concentric ridges or striations; umbones small, slightly opisthogyrous. Hinge heterodont, with a somewhat elongately oval internal ligament; a single styliform more or less obtusely pointed cardinal tooth in the right valve and two curved lamellate cardinal teeth in the left valve. Lateral teeth somewhat distant, elongate, in the form of two ridges in the left valve fitting into corresponding depressions in the right valve. Adductor impressions subequal, the anterior impression somewhat elongated; pallial line entire. Mantle largely open, with a single pallial suture; no pallial tentacles and no distinct siphons. The foot elongate, linguiform, geniculate, with a byssus consisting of a few long adhesive threads; a byssal groove on the posterior edge of the foot. Gills astartiform, homorhabdic, non-plicate, with three or at most four rows of simple interfilamentar junctions. Interlamellar junctions few, irregular; the external demibranch wanting; the reflected lamellæ of the inner demibranch more or less developed, generally at the anterior end of the gill only and attached to the sides of the foot. Hermaphrodite and protandric.

Jousseaumia heterocyathi, n. sp.

The single cardinal tooth of the right valve bluntly rounded at its extremity, with a narrower pedicle of attachment. The anterior cardinal tooth of the left valve well developed, lamella curved posteriorly; the posterior cardinal tooth a short, ill-defined diverging ridge. Found only in *Heterocyathus.*

Jousseaumia heteropsammiæ, n. sp.

The single cardinal tooth of the right valve styliform, with a bluntly pointed extremity and a broad base of attachment. The posterior cardinal tooth of the left

valve well developed, longer than the anterior tooth, diverging posteriorly, its upper margin excavated to form the ligamentar fossa. Found only in *Heteropsammia.*

The differences in the cardinal teeth between the specimens found in *Heterocyathus* and those found in *Heteropsammia* appear to be constant, and are sufficient to justify my ranking them as distinct species. In addition, the mature individuals of *J. heterocyathi* seem to be rather smaller, the concentric ridges seem to be more prominent and the posterior and ventral margins of the valves appear to be more rounded than in *J. heteropsammiæ.*

As may be seen from an inspection of figs. 2 and 3, the ligament is distinctly dorsal and exterior to the posterior cardinal tooth of the left valve, and is contained in a fossa lying just behind the umbones. The hinge, therefore, is not that of a *Mactra*, to which it has a superficial resemblance from the characters of the lateral teeth, nor yet that of a *Scrobicularia* or *Syndosmya.* It may rather be compared with the hinge of a *Lucina* or *Diplodonta* in which the ligament has become very much shortened and enclosed by the overgrowth of the valve margins dorsally and posteriorly. On the other hand, the excavation of the posterior cardinal tooth suggests a first step in the evolution of the spoon-shaped ligamentar tooth of the Myidæ and many of the Anatinacea (*Thracia*, *Anatina*), and, as will be seen, the anatomy of *Jousseaumia* suggests some affinities with the Anatinacea.

ANATOMY AND HISTOLOGY.

As *Jousseaumia heterocyathi* and *J. heteropsammiæ* do not differ from one another in any important anatomical feature, the following account will apply to both species. A general view of the anatomy of *J. heterocyathi*, as seen in optical section, is given in fig. 1.

The mantle edge is thickened and muscular, but there are no pallial tentacles, no eyes or pigment spots. There is a single pallial suture (figs. 16, 17, 18, *p.s.*) separating a rather elongate anal or exhalant orifice from the large pedo-branchial orifice, the latter extending as far forward as the anterior adductor muscle. The mantle edges are somewhat prominent and the radiating muscle fibres are rather better developed in the region of the anal orifice than elsewhere, but there is no true anal siphon.

The foot is large, more or less linguiform, and geniculate like that of *Cardium.* There is a specially strong muscular band running down the posterior margin of the foot, below the byssus groove, and the sudden contraction of these fibres would have the effect of straightening the foot and enabling the animal to spring like a *Trigonia* or a cockle. It is difficult to conjecture of what use the geniculate and muscular foot can be to an animal leading a sedentary existence embedded in the skin of the *Aspidosiphon* with which it is commensalistic ; but as I find it very well developed in

the youngest forms, I suspect that these may escape from the *Aspidosiphon* chamber and use the foot for progression and for springing on and attaching themselves to an *Aspidosiphon* when projected from the basal aperture of another coral. At all events, there must be some means by which *Jousseaumia* can be transferred from coral to coral, and the highly developed musculature of the geniculate foot suggests that the transference is effected in this manner. The anterior and posterior retractors of the foot are well developed and together form an elongated muscular band, by which the foot appears to be slung up in the mantle cavity. Practically the whole of the viscera are dorsal to this band. The protractor muscle of the foot is also well developed and has a separate muscular slip ventral to the anterior adductor muscle, and it is evident that, in spite of its sedentary habit, *Jousseaumia* shows no degeneration in the organs of progression.

The attachment of the young forms to an *Aspidosiphon* inhabiting another coral would be effected by means of the byssus, which has the form of a moderately stout thread, branching and ending distally in adhesive enlargements. The posterior edge of the foot is furrowed by a well-marked byssus groove leading into a byssus cavity at the hinder end of the foot. As the structure of the byssus gland and the mode of formation of the byssus has been a subject of dispute, and as some of my specimens were sufficiently well preserved to enable me to make tolerably accurate observations, I shall describe the histology of this organ in some detail. The whole of the centre of the foot is occupied by a core of more or less polygonal relatively large glandular cells which appear pale in sections stained with borax-carmine and picro-indigo-carmine, but stain deeply in hæmatoxylin or safranin. With the last-named dye the gland cells stain brilliant scarlet, and the stain is shown by high powers of the microscope to be confined to minute granules with which the cells are stuffed. The behaviour of these cells and granules will be described later. The byssus groove begins as a very shallow furrow near the pointed extremity of the foot, and gradually deepens as it passes dorsally along the posterior edge of the foot, eventually ending in a duct which enlarges to form a considerable byssus cavity contained in the upper part of that organ. Fig. 4 is a section taken through the open part of the groove near the middle of the foot. It shows the structure described by CARRIÈRE (**5**) and HORST (**8**), namely, a furrow of irregular shape opening to the exterior, and in the depth of the furrow a crescentic gutter or demi-canal ("halbmondförmige Rinne") bounded on either side by a projecting fold. Contrary to the statements of previous authors, I find in *Jousseaumia* that the furrow is lined by a low, non-ciliated epithelium continuous with that of the external surface of the foot. This epithelium has a distinct cuticle, staining blue in picro-nigrosin or picro-indigo-carmine, and though I am unwilling to make a positive assertion in consequence of the indifferent state of preservation of my specimens, I can say that I was unable to find any trace of cilia either in the furrow or on the external surface of the foot. The crescentic demi-canal, on the other hand, is lined by larger cubical or short columnar cells, with

clear cell contents and rounded nuclei, and these cells are very distinctly ciliated. Fig. 5 represents a section taken through the duct of the byssus cavity, shortly above the point where the lips of the furrow have united to enclose a canal. It can easily be seen that the duct consists of two portions, (*a*) a lower portion whose epithelium is continuous with that of the open furrow and, like it, is non-ciliated and provided with a cuticle; the walls of this region are thrown into a number of folds; (*b*) an upper portion continuous with the crescentic demi-canal, and lined by the same clear ciliated cubical or columnar cells. Fig. 6 represents a section through the middle of the byssus cavity. At the upper (really the anterior) end of the cavity is the crescentic demi-canal lined by the same clear ciliated cells as before. The remainder of the cavity is broken up by septa, of which two thick folds on either side of the demi-canal, a central partition springing from the lower (posterior) end of the cavity, and two minor lateral folds may be particularly noticed. These septa are covered by a ciliated epithelium, evidently of the same nature as that lining the demi-canal, but the cells are very much elongated and enlarged at their outer extremities. Those on the thick lateral folds are especially long, and diverge in a fan-shaped manner from the band of connective tissue and muscle fibre which forms the centre of the fold. This figure agrees in most respects with CARRIÈRES' drawing of the byssus cavity of *Cyprina islandica* (**5**, fig. 12, B). In a section taken through the deeper end of the byssus cavity, the characters of the epithelium are the same as those of the preceding section, but the cavity has been divided into two by the forward extension of the median septum, the crescentic demi-canal has disappeared, and the lateral septa are smaller. These two anterior prolongations of the byssus cavity end blindly close beneath the pedal ganglia. These three figures are drawn from horizontal sections of the whole animal, and are therefore nearly transverse sections of the foot. Fig. 7 is a highly magnified drawing (ZEISS' $\frac{1}{12}$ immersion) of a transverse section of the whole animal, which therefore cuts the foot and byssus cavity obliquely. It corresponds to the top part of a section rather anterior to that shown in fig. 6. The section was stained with safranin and licht-grün, and does not show the cell contours very clearly, but the granules of byssogen, stained bright scarlet, are very clearly seen. At *by.gl.* are seen the large polygonal glandular cells occupying the central part of the foot. On either side these cells may be seen to be breaking up and their granules are streaming outwards along definite lines to pass either into the central tongue-shaped projection (which is a part of the here incomplete median septum) or into the lateral swellings projecting into the byssus cavity. As they pass outwards, the granules form little pyriform or club-shaped masses, whose swollen ends are directed towards the lumen of the byssus cavity, and it is evident that they are travelling, probably by intercellular paths, to be discharged into the lumen, and there converted into the material of the byssus. The granules themselves are clearly not byssus substance, but "byssogen," as the lumen of the cavity is filled with a granular material (not shown in the figure) which is not stained either by

safranin or hæmatoxylin, and the byssus itself is similarly unaffected. The interest of this observation consists in the demonstration that the byssus gland-cells, like those of sebaceous follicles, are broken up to form the secretion, and that the secretum travels in and among the epithelial cells for relatively long distances until it reaches the lumen into which it is finally discharged. Thus the existence of a great mass of gland cells, forming a central core to the foot, and apparently distant from the byssus cavity and groove, is satisfactorily explained. The secretion is not confined to the byssus cavity, but throughout my sections I find the same indications of granules streaming between the ciliated cells of the crescentic demi-canal, but not between the non-ciliated epithelial cells of the furrow. In spite of some differences in detail, which can be accounted for by the widely different genera examined by us, my observations agree in all fundamental particulars with those of Horst (8). The byssus, as he maintained, is undoubtedly a secretion product and not a cuticular structure. Comparing Horst's figures of *Dreissensia polymorpha* (*loc. cit.*, plate xi., figs. 2, 3, and 4) with mine, it will be seen that in the latter species the byssogenous glands are concentrated in the region of the demi-canal, and that there are numerous mucus glands, of which I could find no trace in *Jousseaumia*. And whereas he shows numerous branching and anastomosing canals passing from the cells of the byssus gland between the epithelial cells of the demi-canal, these canals becoming narrower in diameter as they approach the lumen of the byssus cavity, and gives no indication of the breaking up of the cells themselves to form the secretum, I find that the cells are broken up and the secretion travels (probably) between the epithelial cells in the form of streams or strings whose ends nearest the lumen are swollen. It appears that in both cases the secretum follows intercellular paths, and that in both cases it has the form of granules which are converted in the lumen of the byssus cavity, probably by the action of a ferment, into the material of the byssus.

The Alimentary Canal.—The labial palps are relatively large, and the upper and lower palps pass respectively into the upper and lower lips. Posteriorly the labial palps are continuous with the anterior ends of the gill plates. The palps are richly ciliated, the cilia being borne by large cubical epithelial cells with a very distinct limiting membrane, but the surfaces of the palps appear to be smooth, and not thrown into ridges as is usually the case in Lamellibranchia. The mouth leads into a buccal cavity lined by somewhat elongated columnar epithelial cells continuous with those covering the labial palps, and provided, like the latter, with a very distinct limiting membrane or cuticle, through which the cilia project. The pharyngeal cavity is wide and strongly compressed dorso-ventrally. As it passes back into the œsophagus, the shape of the lumen, as seen in transverse section, alters. There is a diamond-shaped central lumen (fig. 8), the lateral angles of which are produced into lateral diverticula, suggestive of a comparison with the œsophageal pouches of Gastropoda. Such pouches are only known in the Protobranchia among the Lamellibranchia, and in them, *e.g.*, in *Leda pella*, as figured by Pelseneer (11),

they are much more highly developed than in *Jousseaumia*, but there is a correspondence between the thinner epithelium lining the lateral pouches in his figure and in mine which leads me to believe that we have here an indication, though in a very much reduced form, of these ancestral structures.

The œsophagus is triangular in section and lined by a richly ciliated columnar epithelium. It passes insensibly into the capacious stomach, whose anterior walls are richly ciliated (fig. 13, *st.*), but posteriorly the lining epithelium changes in character. Laterally and ventrally the cells retain their columnar epithelial character, but dorsally (figs. 14 and 15, *gl.c.*) they lose their cilia and become glandular. The cells throughout this region are rather long and columnar, and are full of green refringent granules. It is in this region that the thick cuticular lining of the stomach begins, and I have little doubt that these glandular cells of the dorsal wall secrete the cuticle, and give rise to the crystalline style with which the cuticle is continuous. The liver lobes are four in number, a right and left dorsal and a right and left ventral. They open into the stomach near its posterior end, just in front of the commencement of the intestine and cæcum, by wide ducts on either side, the ducts of the dorsal and ventral lobes of each side uniting just before they open into the stomach. The liver cells were too much macerated to enable me to say anything definite about their histological characters. The left upper end of the stomach is prolonged into a large conical cæcum (figs. 1, 16, and 17, *cæ.*), which projects backwards into the posterior part of the visceral mass and is a conspicuous object in specimens mounted whole. The cæcum is lined throughout by a very definite cubical epithelium, whose cells bear short, stiff, bristle-like cilia, as is the case in the cæca of other Lamellibranchia. In the anterior part of the cæcum the cells of its dorsal wall are transitional between the ordinary cæcal cells and those of the dorsal wall of the stomach, for they are filled with the green refringent granules, while retaining their cubical character and their stiff brush-like cilia. The cæcum is separated from the stomach by a constriction, and at the constriction the epithelial cells are elongated and their ends are produced into rather long irregular processes, apparently formed of fused cilia. These processes seem to form a straining apparatus, preventing particles of any size from entering the cæcum, for while the stomach, intestine, and rectum are full of the skeletons of diatoms, the cæcum is always devoid of such contents. The crystalline style is very large in some specimens, but small, or even wholly absent, in others. It projects some way forward into the stomach and some way back into the cæcum, but seldom extends to the posterior end of the latter.

The intestine leaves the stomach on the right lower side, close to the opening of the cæcum. It runs backwards as a widish, thin-walled ciliated tube as far as the posterior end of the cæcum, where it turns upwards and forwards to reach the dorsal surface of the visceral mass; there its diameter narrows to form the rectum, and it bends sharply backwards, running parallel with the posterior margin of the shell

over the posterior adductor muscle to end in the anus. The rectum traverses the pericardium, and is wrapped round by the ventricle.

The Circulatory System is of the typical lamellibranchiate character, and requires no special description. The ventricle, as has been mentioned above, is traversed by the rectum. The auricles are excessively thin and can only be distinguished with difficulty in sections. Owing to the minute size of the animal the relations of the principal blood sinuses could not be determined with certainty, but I was able to distinguish a large ventral sinus above the muscular band formed by the anterior and posterior retractor muscles of the foot, and there are the usual afferent and efferent branchial sinuses at the bases of the gills.

The Gills, as may be seen by an inspection of fig. 1, are of a very simple type. The outer demibranch is wanting, a feature which *Jousseaumia* shares with the Lucinidæ, *Corbis*, *Scioberetia* and the Teredinidæ. The direct lamella of the inner demibranch is always well developed, and may be described as consisting of about 18 filaments, united at regular intervals by three, or in large specimens by four, rows of non-vascular interfilamentar junctions. The reflected lamella is present in many adult individuals, but is either absent or very feebly developed in others, and it is always absent in young and immature specimens. When present, it is confined to the anterior region of the demibranch, and the upper edge of the reflected lamella is fused to the body wall along the line of junction of the foot and the visceral mass. Posterior to the foot, where the reflected lamella is absent, the lower edge of the direct lamella of one side is, in all but very young individuals, fused with the lower edge of the corresponding lamella of the other side. If the reflected lamella is absent in the region of the foot, its place is taken by a continuous sheet of membranous tissue, which is attached to the sides of the upper part of the foot. Below and behind the posterior adductor muscle the upper edges of the direct lamellæ are connected with the mantle (figs. 18 and 19), and the result of this arrangement is that the gills divide the pallial cavity into an inter-lamellar or supra-branchial chamber, opening behind by the anal pallial aperture, and a large infra-branchial chamber.

Though I have spoken of filaments, the gills are not developed as separate filamentar outgrowths which subsequently form the above described unions with one another and the body wall and mantle, but by the fenestration of a pair of lateral folds of the body wall, as has been described by other authors for *Cyclas* (Stepanoff, **14**), *Teredo* (Hatschek, **7**), and *Scioberetia* (Bernard, **2**). Although I have not been successful in finding the earliest stages of gill development, I have a complete series of post-larval stages showing that the fenestration proceeds from before backwards, and that new fenestræ are added at the posterior ends of the two gill membranes until the adult stage is reached. Fig. 27 represents a young *J. heterocyathi* in which there are five fully formed fenestrations and the commencement of a sixth posteriorly. Fig. 28 is a drawing of a somewhat older individual

with seven fenestrations. In the youngest form of which I have cut sections the fenestrated gill lamellæ are not reflected, and at the sides of the foot the lamellæ of opposite sides are quite free from one another and from the body wall and foot. Behind the foot the lower edges of the lamellæ of opposite sides are united by a band of connective tissue, and still further back the organic connection between the lower ends is more complete; a vascular connection is established, and at the extreme hinder end of the gill, where fenestration is still in progress, the gill lamellæ of the two sides are blended in a mass of embryonic connective tissue channelled by numerous irregular blood sinuses. It follows from the above description that, if we speak of the bars between the fenestræ as gill filaments, they are at all stages of growth organically united in longitudinal series at their lower ends, and as the filaments assume their complete histological structure, the chitinoid-supporting skeleton of the filaments forms a dorsal and a ventral arcade, the upper end of each hollow chitinoid gill bar curving forward to unite with the bar in front of it, and a similar connection is eventually established at its lower end. In young specimens, however, the skeletal bars pass below into a mass of undifferentiated connective tissue. As growth proceeds, this undifferentiated tissue at the lower edge of the anterior part of the gill lamella grows out in the form of a membrane, and as it grows the membrane is reflected along the sides of the foot and grows upwards, becoming fenestrated as it grows, and eventually the upper edge of what we now recognise as the reflected lamella becomes attached to the body wall along the line of union of the foot and visceral mass, thus completing the separation between the supra-branchial and infra-branchial chambers. It would, perhaps, be more correct to say that, as the reflected lamella grows upwards, the fenestræ of the direct lamellæ extend into it. When the adult relations are established, the chitinoid skeletal bars of the filaments form an arcade along the upper edge of the reflected lamella where it is attached to the body wall. In those adult individuals in which the reflected lamella is imperfectly developed or absent (and such individuals are not uncommon in both the species under consideration), it would appear that there is an arrest of development, and that the larval condition of the gill becomes permanent in the adult. This arrest of development suggests that the gills of *Jousseaumia* are degenerating. As may be expected from the order of formation of the gill fenestræ, the anterior gill filaments are the longest, and they decrease progressively in length from before backwards.

In the youngest specimens there are no interfilamentar junctions, but these are added in the course of growth, and, as can readily be understood from a consideration of the manner in which the gills are formed, the posterior filaments have fewer junctions than the anterior, as has been described by BERNARD for *Scioberetia*.

A few irregularly scattered interlamellar junctions are formed soon after or during the growth of the reflected lamella. These interlamellar junctions are vascular, whereas the interfilamentar junctions are non-vascular.

Owing to the very small size of *Jousseaumia* and the minuteness of the elements composing the gill filaments, I had some difficulty in making out the details of the gill structure, but as some few of my specimens were well preserved and the very minuteness of the objects was of assistance in enabling me to study optical sections under a high power, I have been able to make out some interesting points not hitherto recorded. The individual filaments are slender, and, except for the fact that their interlamellar edges are broader than their frontal edges, they have the usual lamellibranchiate structure. The central cavity is lined by the usual chitinoid layer, thickened at the sides. I could not determine from my sections whether the cavity is divided by a transverse partition into an afferent and an efferent canal, but the appearances seen in optical section lead me to think that it is. The greater number of my specimens when mounted whole and viewed in optical section seemed to possess a large number of closely set ciliated discs, and the late Professor WELDON to whom I showed my preparations was of the opinion that there could be no doubt that ciliated discs were present. Further investigations led me to modify my first opinion, but disclosed an arrangement of the ciliated cells that merits a detailed description.

Figs. 20 and 21 are transverse sections through the gill filaments, the former of a somewhat young and the latter of an adult individual. The triangular shape of the section of the filament with the narrower frontal edge and broad interlamellar base is seen to be due to the great size and thickness of the cells marked *l.c.* Following the usual terminology, the short cilia on the narrow frontal edges may be called the frontal cilia; they are borne on two or three wedge-shaped cells with small nuclei, and the more laterally disposed frontal cilia are longer than the others, so much longer that I was disposed to regard them as latero-frontal cilia, but I do not think that they can be identified as such. The true latero-frontal cilia are very long and rather stiff and are borne on very definite longitudinal rows of columnar cells arranged in single series. These cells are large, with conspicuous round nuclei at their bases, and can be very clearly seen in optical section when the surface of the filament is brought into focus, fig. 22A. Their position and shape is clearly shown in the sections figs. 20 and 21, *l.f.* Following on these are one or two non-ciliated interstitial cells, and the sides of the filaments just above their basal angles are occupied by longitudinal rows of very large oblong cells with flattened elongated nuclei. These cells are best seen in optical section by focussing below the latero-frontal cells, as in fig. 22B, but they are clearly distinguishable in transverse section, though their elongate shape is, of course, not shown in this case. These cells bear a large number of very fine cilia, which interlock with those of adjacent filaments, and the interlocking is so effectual that when the tissues are contracted by the action of reagents the limiting membranes of the cells are torn off and remain adherent to the cilia in the interfilamentar spaces (figs. 20 and 21). The interlamellar bases of the filaments are covered by a few flattened non-ciliated cells with small nuclei. The false appearance of ciliated discs observable in so many of my specimens is due to the fact that in

macerated or much contracted gills the large oblong cells become loosened from their attachment to the filament and become bent up in a crescentic form with their convexities outwards. In this condition, when the cilia remain attached to them, they may very easily be mistaken for ciliated discs, and it was only after studying well-preserved preparations with the highest powers of the microscope that I discovered the real state of the case. As far as I am aware, very large elongated cells of this shape bearing the lateral cilia have not been described before, and they seem to be peculiar to *Jousseaumia*. It is, as I have said, possible to regard the longer cilia on the frontal edges as latero-frontal, and in that case the very long stiffer cilia succeeding them would be lateral cilia, and the long fine interlocking cilia borne by the brick-shaped cells might be regarded as occupying the position of and being homologous with ciliated discs. On this view the gill of *Jousseaumia* would have to be regarded as a primitive form of filibranch gill, in which the interlocking cilia are arranged in continuous lines and are not differentiated into isolated ciliated discs. But this view is hardly tenable. The gills of *Jousseaumia* are not filibranch, for they have well-developed interfilamentar junctions. Moreover, the interlocking cilia, in addition to their being arranged in longitudinal lines and not in groups, are actually finer and longer than the fronto-lateral cilia, and lack the short, stiff brush-like character of the cilia of true ciliated discs. The fact remains, however, that they interlock, and that there is therefore a ciliary union in addition to an organic union between the filaments of *Jousseaumia*. It seems to me probable, however, that the physiological rôle of the interlocking cilia is rather to form a barrier preventing solid particles from passing between the filaments than to give mutual support to the filaments, and this view is supported by their extreme fineness, while the coarser latero-frontal cilia projecting from the corners of the frontal edges are evidently effective in sweeping solid particles over the surfaces of the gills towards the labial palps and mouth.

The interfilamentar junctions are arranged in regular rows. In most specimens there are three such rows in the anterior part of the direct lamella and one or two rows in the reflected lamella. As has been stated, these junctions are non-vascular and are formed as secondary outgrowths from the filaments, bridging across the fenestræ at regular intervals. As may be seen in figs. 17 and 21, these interfilamentar junctions are curved bars, continuous with the chitinoid lining of the central cavity of the filament, but the junctions themselves are solid, and as they are only clothed by a very thin protoplasmic sheath, they do not establish any vascular connection between adjacent filaments. As seen in section, the interlamellar edge of each filament appears to be prolonged to form a pair of bars which curve round to unite with corresponding outgrowths from the adjacent filaments. The lower part of fig. 22 shows the interfilamentar junctions as viewed in optical section under a very high power of the microscope. As a rule the interfilamentar bars are single, but occasionally they are double, as shown in the middle of the figure. The chief point of interest is that the bars are clearly shown to be formed by the agency

of special cells, whose nuclei are grouped about the broad bases of attachment of the bars to the filaments. These nuclei are visible in section in fig. 21*x*. There can be no doubt that the interfilamentar junctions are formed by the agency of these cells, for their position at the attached ends of the bars is invariable, and they are not to be distinguished elsewhere. Moreover, by looking through numerous preparations, I have been able to recognise these groups of cells at points where the interfilamentar junctions are in process of formation, and have seen in optical section the processes formed by the cells projecting from, but not yet bridging over the interval between adjacent filaments. These chitin-forming cells do not appear to have been recognised by previous observers, but they are probably included in the general and somewhat vague term "sub-filamentar" tissue. BERNARD (2) gives a drawing of groups of stellate cells in *Scioberetia*, which appear to coincide in position with those which I have described, but he does not attribute any special function to them, and merely refers to them as components of a "substance conjonctive transparente à nombreuses cellules" (*loc. cit.* p. 374). It is evident from a comparison of the sections drawn in figs. 20 and 21, that these junction-forming cells in *Jousseaumia* are differentiated from the flat non-ciliated cells covering the interlamellar edges of the filaments.

THE PERICARDIUM AND RENAL ORGANS.—Owing to the minute size and the contracted state of my specimens, the relations of these organs presented great difficulties. The pericardium is a more or less triangular sac, relatively of considerable size, lying above and in front of the posterior adductor muscle. It is traversed obliquely by the rectum, and the ventricle of the heart surrounds the latter for a considerable part of its course through the pericardium. The whole of the inner lining of the pericardial walls is glandular, constituting an extensive pericardial gland, but the glandular epithelium does not appear to extend to the investment of the ventricle and auricles. Glandular epithelia are the first to suffer from the effects of long immersion in spirit, and the preservation of my specimens was not good enough to allow me to make out the details of the pericardial glandular cells with any certainty. The most that I am able to say is that they are rather large irregularly shaped cells with oval nuclei, and coarsely granular contents which stain faintly blue in picro-indigo-carmine.

The kidneys are conspicuous from the large concentrically striated concretions which they contain. These concretions are contained in a highly vacuolated protoplasmic lining of the renal sacs. The right and left renal sacs are fused together for such a considerable extent in the middle line, below the floor of the posterior end of the pericardium, that their paired nature is obscured, and can only be recognised by an examination of the paired ducts and the paired anterior and posterior horns into which the median sac is produced. Such an extensive fusion of the two kidney sacs is characteristic of the more specialised forms of Lamellibranchia, particularly of the Myacea, Pholadidæ and Anatinacea (PELSENEER, 12), and my sections through this region of the body bear a considerable resemblance to the section through the

kidneys of *Lyonsiella abyssicola* and *L. norvegica* figured by PELSENEER (**11**). The median sac formed by the fusion of the right and left kidney sacs in *Jousseaumia* lies just in front of and above the posterior retractor pedis muscle, near where the latter bifurcates to be attached to the right and left valves of the shell. The two posterior horns of the sac are of considerable length, and extend along the outer sides of the diverging bundles of the retractor pedis muscle, extending blindly just below the anterior end of the posterior adductor muscle. The anterior horns of the sac are smaller and pass to the outside of the retractor pedis muscle. The median sac and its anterior and posterior prolongations are lined throughout by a thick vacuolated layer of protoplasm containing relatively large oval nuclei, but I was unable to distinguish any cell outlines. The renal concretions lie in the vacuoles and are similar to those described and figured by PELSENEER (**11**). The relations of the renal ducts and the reno-pericardial canals are shown in fig. 23, and the renal ducts are shown in section in figs. 25 and 26, *Re.d.* They are short canals lined by a cubical ciliated epithelium and open into the supra-branchial cavity, in close contiguity to the genital apertures, on a small papilla situated to the outside of the visceral commissure. The reno-pericardial ducts are very minute, and it was difficult to discover them even with the aid of the highest powers of the microscope. They are extremely fine ciliated ducts opening into the floor of the renal sac not far in front of the uroducts. Each reno-pericardial duct runs forward close below the external part of the floor of the median renal sac, and, passing to the inside of the uroduct, turns upwards and opens by a minute ciliated aperture into the pericardial cavity.

THE NERVOUS SYSTEM.—This is of the usual lamellibranchiate type, and presents few features of interest. The nerve ganglia are relatively of great size, as may be seen in figs. 9, 12, and 19. Their proportions, relatively to the whole size of the animal, may be described as larval, and this, coupled with the fact mentioned below (p. 257), suggests that the sexual products in *Jousseaumia* are precociously developed, and that we have, in fact, an example of pædogenesis. In the cerebro-pleural ganglia the separate groups of nerve ganglion cells forming the cerebral and pleural moieties of the ganglia are easily recognisable, but the cerebro-pedal and pleuro-pedal connectives leave the fused ganglia as a single nerve. The otocysts are situated above the hinder part of the large nerve mass formed by the fused pedal ganglia, and are quite separate from the ganglia and contained in special compartments of the general body-cavity or hæmocele (fig. 13, *ot.*). Each otocyst contains a single large otolith. The visceral ganglia are of great relative size, and the posterior pallial nerves are very stout. I was unable to find any trace of an osphradium in the form of a specialised patch of epithelium in the neighbourhood of the visceral ganglia, or on the course of the posterior branchial nerves.

THE GONADS AND GONADUCTS.—*Jousseaumia* is monœcious, and, as is usual among hermaphrodite lamellibranchia, is protandric. By far the greater number of the individuals examined by me contained spermatozoa only, but in some few both ripe

spermatozoa and developing ova were present in the gonads, and in about half a dozen cases the gonads contained ova only and were enormously enlarged, displacing the other viscera in the visceral mass. It would appear that *Jousseaumia* is also, to a certain extent, pædogenetic, for I discovered ripe spermatozoa in a considerable number of young forms which were clearly immature as regards the structure and development of the shell and gills.

The gonad itself shows very few traces of paired structure, and varies very much in shape and extent, according as it contains spermatocytes and spermatozoa only, or developing ova or ripe ova. It may be described as consisting of a median vestibule lying in front and ventrad of the kidney and pericardium, opening behind by paired ducts on the reno-genital papillæ, and produced anteriorly into a dorsal and a ventral tubular diverticulum. The diverticula are lined by the germinal epithelium, from which first spermatocytes, then, when the spermatozoa have ripened, oocytes, are produced. In the first stage, when the protandric phase is in evidence, the extent of the gonad is small, as is shown in fig. 1. The dorsal diverticulum extends forward and upward from the vestibule below the floor of the anterior part of the pericardium, and is continued forward below the rectum as far as the point where the latter bends sharply back on itself. The ventral diverticulum is a very short tubular outgrowth from the lower and anterior face of the vestibule, and lies ventrad of the stomachal cæcum. The dorsal or anterior end of the dorsal diverticulum is bifurcated, and the two branches often lie on either side of the rectum, this and the existence of paired gonaducts being the only evidences of paired structure in the body of the gonad. The ventral diverticulum is never bifurcated. Spermatogenesis is effected mainly, though not exclusively, in the dorsal diverticulum, which in many specimens is filled with spermatocytes and spermatids in different stages of development, but the state of my preparations did not admit of my making minute investigations on this subject. The vestibule, in this phase, is filled with ripe spermatozoa, and at a somewhat later period the whole gonad contains a mass of ripe or nearly ripe spermatozoa. This was the most common condition in the numerous specimens I examined ; only in two of them could I find evidence of the simultaneous formation of ova and spermatozoa, and in those there were many ripe and a few developing spermatozoa in the dorsal diverticulum, the vestibule was filled with ripe spermatozoa, and developing ova were observed in the ventral diverticulum. The more usual course appears to be that the protandric phase is followed by a short resting stage, during which the diverticula of the gonad are empty and reduced in size, though the vestibule may remain full of spermatozoa. This is succeeded by an active development of ova in both diverticula, which become enormously distended and push their way forward among the viscera, displacing the latter to a very considerable extent. Posteriorly the vestibule bifurcates to form the right and left gonaducts. These ducts, wide at first (fig. 24, *go.d.*), rapidly diminish in diameter, and passing outwards and backwards, open just to the outside of and behind the renal apertures on the reno-genital papillæ on either

side. The most remarkable feature about the gonaducts is that each, just before its external opening, is joined by the short and contracted duct of an ovoid vesicle (*Vs.*, figs. 1, 24, 25) which, in nearly all cases, is filled with ripe spermatozoa, and is clearly a seminal vesicle, in which the ripe spermatozoa are stored up pending the development of the ova. These seminal vesicles, which form very conspicuous objects in sections, are lined by a well-defined, flattened, and as far as I could determine, non-ciliated epithelium, and their relations to the gonaducts are best seen in the series of sections, figs. 24, 25, and 26, drawn under a high power of the microscope. The presence of specialised accessory organs in the shape of vesiculæ seminales on the gonaducts is, as far as I know, a unique feature among the Lamellibranchia, though PELSENEER (**12**) makes mention of an accessory gland on the male duct of *Cuspidaria*, but this gland is not described in his detailed account of the anatomy of the genus. The numerous specimens of *Heteropsammia* and *Heterocyathus*, sent me by Professor HERDMAN, were collected in February and March, and as the more mature individuals of *Jousseaumia* inhabiting them are nearly all in the same sexual condition, viz., in the protandric phase, it seems probable that in this genus there is a seasonal alternation of male and female maturity. If this conjecture is right, it is evident that the vesiculæ seminales serve as reservoirs for the spermatozoa, which are stored up until the ova are ripe and ready to be discharged from the gonaducts.

Hermaphroditism, though it is not uncommon among the Lamellibranchia, is only characteristic of a single sub-order, the Anatinacea. In all the hermaphrodite forms protandry is the rule, as in *Jousseaumia*, and this is markedly the case in the Anatinacea, as shown by PELSENEER (**11**). In this sub-order, the ovaries and testes are separate, the ovaries being dorsally and the testes ventrally situated in the visceral mass. In *Pandora*, *Thracia*, and *Lyonsia*, the oviducts and spermiducts open separately by contiguous orifices on each side of the body, and the same is the case in *Lyonsiella*, but in this last genus the male and female apertures open very close together on a small genital papilla (PELSENEER, **11**). In *Jousseaumia* the conditions are different; the gonad is single and alternately male and female in function, and there is only a single gonopore on each side. But its structure is interesting as indicating the manner in which the separate ovaries and testes of the Anatinacea may have been evolved. The dorsal and ventral diverticula of *Jousseaumia* correspond in position with the ovaries and testes of the Anatinacea, and, as I have shown, they are to a certain extent specialised, since the production of spermatozoa is nearly exclusively confined to the dorsal diverticulum. If the two diverticula were to become separate and acquire separate openings to the exterior and the function of producing ova were confined to the one, and the function of producing spermatozoa to the other, we should have a condition of things nearly identical with that of the Anatinacea. It must be observed, however, that in the latter group the testes are ventral, whereas in *Jousseaumia* the male diverticulum is dorsal, and at a later stage both diverticula become female.

Although I made a careful search, I was unable to find any ova or embryos in the supra-branchial chamber. It does not necessarily follow that *Jousseaumia* is not incubatory, and that the ova are not fertilised, and undergo the earlier stages of development in the branchial cavity, for as I have pointed out, there is probably a seasonal alternation of sexual maturity, and the specimens at my disposal were mostly in the male condition. Even those which had advanced beyond this stage and contained numerous ova in the gonads, did not give evidence of complete female maturity. In one specimen of *Heteropsammia* I found, in the *Aspidosiphon* chamber, a number of small ovoid ova, each surrounded by a thick radially striated egg-membrane, but I have no evidence that these are the ova of *Jousseaumia*. Nor was I successful, after a prolonged and careful search, in finding any larval or embryonic forms much younger than the specimen shown in fig. 27, though in every coral there was an abundance of young forms representing every stage of later growth. The specimen depicted in fig. 27 displays clearly the larval shell or prodissoconch, with its rectilinear hinge-line and internal ligament. A single-growth lamina has been added at the edge of the prodissoconch, so the animal cannot have passed very far beyond the larval stage. The principal organs of the body are, however, well developed. The anterior and posterior adductor muscles are fully formed, as is usual in young Lamellibranchs; the foot has the geniculate characters of the adult; the retractor and protractor muscles of the foot have the same relative size and importance as in the adult; the labial palps are well formed, and in the alimentary canal all the features of the adult—pharynx, œsophagus, stomach, cæcum, liver and intestine—are clearly distinguishable. Only the nerve centres and the gills retain embryonic characters. In the nervous system the ganglia are still larger, relatively to the whole size of the animal, than they are in adult, and the connectives are relatively very thick. In the cerebro-pleural ganglia the double nature of each member of the ganglion-pair, only recognisable in section in the adult, is evident in a surface view (fig. 27, *cg.*). The gills are in an early stage of development and show five fenestrations, with a commencement of a sixth. The organisation is much more advanced than, for instance, in the youngest *Scioberetia* figured by BERNARD (**2**, plate XV., fig. 4). Not only is the internal organisation well advanced, but the hinge does not show the characteristic teeth of the prodissoconch, although the valves have hardly grown beyond the prodissoconch stage. On the contrary, there is no trace of a provinculum, the anterior cardinal teeth are clearly developed, and the large lateral teeth are being formed by folds of the mantle edge just above the anterior and posterior adductor muscles. In the specimen shown in fig. 28 there are four growth laminæ outside the prodissoconch. The organisation is somewhat more advanced than in fig. 27; in particular the nervous system and labial palps have assumed their adult proportions and the gills are larger and have acquired seven fenestrations, but as yet no interfilamentar junctions. The anterior cardinal teeth of the hinge are more distinct and clearly interlock with one another, and a deposition of calcareous matter round

the attachments of the ligament foreshadows the formation of the posterior cardinal tooth and the ligamentar fossa. In later stages, with seven or eight growth laminæ outside the prodissoconch, the adult characters of the hinge are fully established. It would appear, then, that, as compared with the size of the shell, the visceral organs and the permanent hinge teeth are precociously developed in *Jousseaumia*, and the suppression of the provinculum and consequent abbreviation of the several stages in the evolution of the heterodont hinge may account for the ligament remaining internal and therefore in its larval condition instead of being shifted to an external position.

CONCLUSION.

I have given a full description of this interesting little Lamellibranch, because, as it seems to me, it is incumbent on students of this class to give a full anatomical account of the various forms that come under their notice. A detailed account of the anatomy of various Lamellibranchs is needed before many questions of classification can be finally settled. The researches of PELSENEER (**10**) have broken ground in this direction, but subsequent authors have not followed his example by dealing with the whole anatomy of the species they have investigated. The work of RIDEWOOD (**15**), dealing with a large number of species of all orders of the Lamellibranchia, is confined to a detailed exposition of the gill-structure, and though it forms a valuable contribution to our knowledge of this single feature of Lamellibranch anatomy, its main result has been to show how little the characters of a single organ are to be relied upon in framing the smaller subdivisions of a system of classification. There are at the present time few malacologists who will question the importance of gill-structure as a basis of the general classification of the Lamellibranchia and their division into the orders Protobranchia, Filibranchia, Eulamellibranchia and Septibranchia meets with general acceptance, the more so because these orders correspond very closely with those based upon a study of the hinge characters. But when we come to subdivide the orders into sub-orders and to arrange the latter in families, and especially when we attempt to estimate the relationship and probable lines of descent of the various families grouped together in the sub-orders, the structure of the gills becomes of less value to us. Thus, to take a single instance, in the family Donacidæ we find plicate and non-plicate, homorhabdic and heterorhabdic gills with almost every variety of interfilamentar and interlamellar connection. In the large sub-order Submytilacea, we find the simple Astartiform gill at one end of the order and the extremely specialised complex gills of the Unionidæ at the other, and no very definite series connecting the two. PELSENEER (**10** and **12**) characterises the Submytilacea as Eulamellibranchs with smooth, *i.e.*, non-plicate gills, but RIDEWOOD (**15**) has shown that the gills of *Diplodonta oblonga* and *Monocondylæa* are slightly and those of *Corbicula lydigina* markedly plicate. On the other hand, smooth or

non-plicate gills are common among other sub-orders of Eulamellibranchia. The detailed study of gill structure has therefore proved disappointing for classificatory purposes, and in trying to trace the connections between the sub-groups of the Eulamellibranchia we are once more thrown back on a criticism of the *ensemble* of the anatomical characters of each family. The difficulty of placing any given genus in its proper position in the system is well illustrated by *Jousseaumia*. Its heterodont hinge, sub-equal adductor muscles, entire pallial line, single pallial suture and very simple gill structure leave no doubt that it must be placed in the Submytilacea, but when one looks for its nearest allies in this very heterogeneous sub-order, the difficulties are considerable, and they are not lessened by the fact that some systematists give a certain character as diagnostic of a family, and then proceed to describe as members of that family genera in which this diagnostic character is wanting.

Thus, *Jousseaumia* shows undoubted affinities to the Erycinidæ (Leptonidæ, Pelseneer, 12). The members of this family are hermaphrodite, the ligament is internal, the foot linguiform, elongated and byssiferous, the gills simple and astartiform, with very little sub-filamentar tissue and scattered interlamellar junctions. Many members of the family are of minute size and some (*Lepton*) are commensal. Bouvier identified *Jousseaumia* as a *Kellia*, and E. A. Smith identified it with Angas' genus *Mysella*, which Fischer (6) regards as closely allied with *Kellia*. I have shown that it cannot be placed in either of these genera, and though it might be regarded as having affinities with *Lepton* or *Lasæa*, because of the single pallial suture, it differs from the whole of the Erycinidæ in the absence of the external demibranch. This last character suggests an affinity with the Lucinidæ, and more particularly with the genus *Montacuta* placed in this family by Pelseneer; *Montacuta* has a single pallial suture, a very long, linguiform, byssiferous foot and a shell which is in many respects similar to that of *Jousseaumia*. The ligament is internal, the anterior adductor impression longer than the posterior, the cardinal teeth have analogous characters, and the anterior border is longer than the posterior, and as a small point of resemblance Pelseneer describes a protractor pedis ventral to the anterior adductor (11, p. 203) which is paralleled by the slip of the protractor in *Jousseaumia*. *Montacuta bidentata* has the habit of living in old shells, and *M. substriata* is parasitic on an Echinid, and the former habit is suggestive of the manner in which *Jousseaumia* may have come into association with the Sipunculid inhabiting the basal chambers of corals. So similar is the shell of *Montacuta* to that of the Erycinidæ that Fischer places it in this family, but its gills not only lack the external demibranch, but the filaments have considerable interlamellar extrusions, the interfilamentar junctions are vascular and in these and other respects so closely resemble the gills of *Lucina* that there can be no doubt that it should be placed, as Pelseneer has placed it, in the Lucinidæ. And for the same reason that *Montacuta* is placed in the Lucinidæ, *Jousseaumia* must be excluded from this family. Its gill

structure is different and it is monœcious whereas the Lucinidæ are diœcious, and there are other anatomical characters in which it differs from *Montacuta* (see Pelseneer, 11, pp. 203, 204).

The only other members of the Submytilacea in which the external demibranch is wanting are the Corbidæ and *Scioberetia*. *Jousseaumia* has clearly no affinities with the Corbidæ, but, as has been pointed out, it has certain features in common with *Scioberetia*. Both are hermaphrodite, commensal or semiparasitic, have a similar gill structure and a single pallial suture, but in *Jousseaumia* the mantle is not reflected over the shell and it therefore must be excluded from the Galeommidæ, to which *Scioberetia* belongs.

The balance of evidence is in favour of placing *Jousseaumia* among the Erycinidæ in spite of the absence of the external demibranch. This last character, taken by itself, is of no systematic importance, since it occurs in forms as far apart as *Lucina*, *Scioberetia*, and *Teredo*. Ridewood has shown that the external demibranch is liable to modification and partial suppression in a large number of widely separated genera, and its total suppression may well be accounted for by changed conditions of life affecting the respiratory and alimentary functions. I have shown that there is evidence that the gill is degenerating in *Jousseaumia*, and that the reflected lamella of the existing demibranch, never very well developed, is rudimentary in a certain number of adult individuals. The conditions which are causing the degeneration of the reflected lamella of the inner demibranch may well have caused the total suppression of the outer demibranch. On the other hand, the details of the gill structure agree very closely with those of the Erycinidæ, particularly with that of *Lasæa*, and the internal ligament, the shell characters, the hermaphroditism and other anatomical features point to a close relationship, particularly to the last-named genus, in which the external demibranch is very short and has no reflected lamella. It may be further observed that *Jousseaumia* presents an interesting example of the admixture of primitive and specialised characters which is so puzzling to the systematist. Ridewood rightly regards the gills of *Astarte* as being among the most primitive of all Eulamellibranch gills. In their essential structure the gills of *Jousseaumia* are still more primitive, but at the same time they are specialised, and specialised in the direction of reduction and degeneration, as is shown by the absence of the outer demibranch, the slight development, and even the suppression of the reflected lamella of the inner demibranch, which in some individuals is only represented by a continuous sheet of tissue reflected and attached to the body wall in the region of the foot. It is obvious that this kind of reduction, if carried still further, would lead to the condition found in the Septibranchia, though I do not mean to suggest that *Jousseaumia* is closely related to this order.

As other evidences of primitive characters we may note, in *Jousseaumia*, the relics of paired œsophageal pouches (if I am right in regarding the lateral grooves in the œsophagus as such), the obvious cerebral and pleural moieties of the cerebro-pleural

ganglia in the young forms, the simplicity of the alimentary tract (but this may be due to degeneration), and such minor characters as the persistence of the internal embryonic hinge ligament, the single pallial suture, &c. On the other hand, the extensive fusion of the kidney-sacs in the middle line is characteristic of more highly specialised Eulamellibranchs, such as the Anatinacea, and the presence of vesiculæ seminales is a unique feature of specialisation in connection with the reproductive apparatus.

Taking all these facts into consideration, we must regard *Jousseaumia* as an offshoot of a primitive Eulamellibranch stock, which in consequence of its commensal habits has been largely modified in the directions indicated, and that its nearest allies are the Erycinidæ and Galeommidæ, which are similarly primitive Eulamellibranchs modified in various directions in relation to their different habits of life.

It is interesting to note that the commensalism between a coral, a sipunculid, and a lamellibranch must be still further extended. In almost every specimen examined, whether of *Heterocyathus* or *Heteropsammia*, I found in the *Aspidosiphon* chamber one or two specimens of a small copepod belonging to the family Harpacticidæ, but as I am obliged to bring this paper to a close to be in time for the issue of the last volume of the "Reports on the Ceylon Pearl Oyster Fisheries," I have not had time to identify the genus and species. Furthermore, *Jousseaumia*, minute as it is, and protected within the *Aspidosiphon* chamber of the coral, is liable to the attacks of parasites. In one series of sections I found a minute trematode, distinguishable as such by its well-developed suckers, encysted in one of the dorsal lobes of the liver, and in another series a larger specimen of what is apparently a trematode, but I could not easily determine its nature from the sections, lying free in the supra-branchial cavity.

LIST OF PAPERS REFERRED TO.

(1.) ANGAS, G. F.—"Description of One Genus and Twenty-five Species of Marine Shells from New South Wales." 'Proc. Zool. Soc.,' 1887, p. 171.

(2.) BERNARD, F.—"*Scioberetia australis*, type nouveau de Lamellibranche." 'Bull. Sci. de la France et de la Belgique,' xxviii., 1895, p. 364.

(3.) BERNARD, F.—"Recherches ontogéniques et morphologiques sur la coquille des Lamellibranches." 'Ann. des Sci. Nat.' (8), viii., 1898, p. 1.

(4.) BOUVIER, E. L.—"Le commensalisme chez certains Polypes madréporaires." 'Ann. des Sci. Nat.' (7), xx., 1895, p. 1.

(5.) CARRIÈRE, J.—"Die Drüsen im Fusse der Lamellibranchiaten." 'Arb. a. d. Zool. Inst. Würzburg,' v., 1882.

(6.) FISCHER, P.—'Manuel de Conchyliologie.' Paris, 1887.

(7.) HATSCHEK, B.—"Ueber Entwicklungsgeschichte von *Teredo*." 'Arb. a. d. Zool. Inst. Wien.,' iii., 1880, p. 1.

(8.) HORST, R.—"Ist der Byssus eine Cuticularbildung?" 'Tijdschr. Ned. Dierk. Vereen.' (2), ii., 1889.

(9.) PECK, R. H.—"The Minute Structure of the Gills of Lamellibranchs." 'Quart. Journ. Micr. Sci.,' xvii., 1877, p. 43.

(10.) PELSENEER, P.—"Contribution à l'Étude des Lamellibranches." 'Arch. de Biologie,' xi., 1891, p. 147.

(11.) PELSENEER, P.—'Introduction à l'Étude des Mollusques.' Bruxelles, 1894.

(12.) PELSENEER, P.—"Mollusca." LANKESTER'S 'Treatise on Zoology,' pt. v. London: A. and C. BLACK, 1906.

(13.) SHIPLEY, A. E.—"Report on the Gephyrea collected by Professor HERDMAN at Ceylon in 1902"; 'Report on the Pearl Oyster Fisheries and Marine Biology of the Gulf of Manaar,' Part I., Roy. Soc., 1903.

(14.) STEPANOFF, P.—"Ueber die Geschlechtsorgane u. die Entwickelung von *Cyclas*." 'Arch. f. Naturgeschichte,' 1865, p. 1.

(15.) RIDEWOOD, W. G.—"On the Structure of the Gills of the Lamellibranchia." 'Phil. Trans.,' B, cxcv., 1903, p. 147.

EXPLANATION OF PLATES.

Lettering in all the Figures.

A.ad., anterior adductor muscle.
A.ap., anal or exhalant aperture.
An., anus.
A.r.p., anterior retractor pedis muscle.
Br.m., branchial muscles.
Bucc., buccal cavity.
By., byssus.
By.c., byssus cavity.
By.g., byssus groove.
By.gl., byssus gland cells.
Cæc., cæcum.
C.g., cerebro-pleural ganglion.
Cr.s., crystalline style.
Cu., cuticular lining of stomach.
Dbr., internal demibranch.
F., foot.
fr., frontal cilia.
gl.c., glandular cells of stomach.
Go., gonad.
Go.a., genital aperture.
Go.c., gonaduct.
Go.d.[1], dorsal diverticulum of gonad.
Go.d.[2], ventral diverticulum of gonad.
Ht., ventricle of heart.
if.j., interfilamentar junctions.
il.j., interlamellar junctions.
l., lateral cilia.
l.c., oblong cells bearing lateral cilia.
l.f., latero-frontal cilia.
Li., liver.
Lig., hinge ligament.
Lm.int., internal lamella of demibranch.
Lm.ext., external lamella of demibranch.
L.p., labial palps.
M., mantle.
Oe., œsophagus.
or.exh., exhalant or anal pallial orifice.
ot., otocyst.
P.ad., posterior adductor muscle.
Pc., pericardium.
P.g., pedal ganglion.
P.r.p., posterior retractor pedis muscle.
P.s., pallial suture.
Ptr., protractor pedis muscle.
Ptr.[1], ventral slip of the protractor pedis muscle.
R., rectum.
Re., kidney.
Re.a., renal aperture.
Re.d., renal duct.
R.pd., reno-pericardial canal.
St., stomach.
Spz., spermatozoa.
Vb., vestibule of gonad.
Vc., visceral commissure.
Vg., visceral ganglion.
Vs., vesicula seminalis.
x., cells of the interfilamentar junctions.

PLATE I.

Fig. 1. An adult specimen of *Jousseaumia heteropsammiæ* lying in the right valve of the shell. × 85.

„ 2. Valves with hinge teeth of *J. heterocyathi*. × 85. *c.*, the single cardinal tooth of the right valve; *c.a.*, the anterior, and *c.p.*, the posterior cardinal teeth of the left valve; *foss.*, ligamentar fossa; *lig.*, ligament; *l.ant.*, anterior lateral, and *l.post.*, posterior lateral teeth; *L.V.*, left valve; *R.V.*, right valve.

„ 3. Valves with hinge teeth of *J. heteropsammiæ*. × 85. Lettering as in the preceding figure.

„ 4. Section through the byssus groove of *J. heterocyathi* highly magnified, showing the ciliated demicanal, *d.c.*, in the depth of the groove; *mus.*, muscle fibres of the foot.

„ 5. A section through the duct of the byssus cavity, higher up than fig. 4. The ciliated demicanal, *d.c.*, retains the same shape as in fig. 4; the remainder of the duct is not ciliated, but lined by a thick cuticle formed by the underlying epithelial cells.

Fig. 6. A section through the byssus cavity. The demicanal, *d.c.*, is still apparent, but the whole cavity is lined by a similar ciliated epithelium. *m.sp.*, median septum; *l.sp.*[1], the thick lateral septa on either side of the demicanal; *l.sp.*[2], smaller lateral septa.

„ 7. A portion of a section through the byssus cavity, somewhat anterior and oblique to the section drawn in fig. 6. The byssus gland cells, *By.gl.*, are seen to be breaking up, and the granular secretum stained red with safranin is passing between the epithelial cells. The granular secretion in the cavity itself is omitted. Zeiss' $\frac{1}{12}$ hom. imm. Comp. Oc. 4.

„ 8 A transverse section through the œsophagus of *Jousseaumia heterocyathi*. *lat.div.*, lateral diverticula of the œsophagus, resembling the œsophageal pouches of Protobranchia. Zeiss' $\frac{1}{12}$ hom. imm. Comp. Oc. 4.

PLATE II.

Figs. 9 to 19. A series of transverse sections through *Jousseaumia heteropsammiæ*. Fig. 9 passes through the cerebral ganglia and fig. 19 through the visceral ganglion pair. All the figures are fully lettered.

PLATE III.

Fig. 20. A section through the ventral end of the demibranch of an immature individual of *J. heteropsammiæ*. Zeiss' $\frac{1}{12}$ hom. imm. Comp. Oc. 4.

„ 21. A section through two adjacent gill filaments of a mature individual of *J. heteropsammiæ*, showing the interfilamentar junctions.

„ 22. Optical sections of two gill filaments of *J. heterocyathi*. A represents the filaments as seen with a high focus, and shows the latero-frontal cilia, *l.f.*, borne on columnar cells. B represents a section as seen with a somewhat deeper focus, and shows the lateral cilia, *l.*, borne on the large oblong cells, *l.c.* C, taken at a still deeper focus, shows the interfilamentar junctions, which are occasionally double, as in the centre of the figure, and the cells *x*, which give rise to the outgrowths forming the junctions.

„ 23. A diagram showing the relations of the kidney, pericardium, and gonads in *Jousseaumia*, from a reconstruction of a series of sagittal sections.

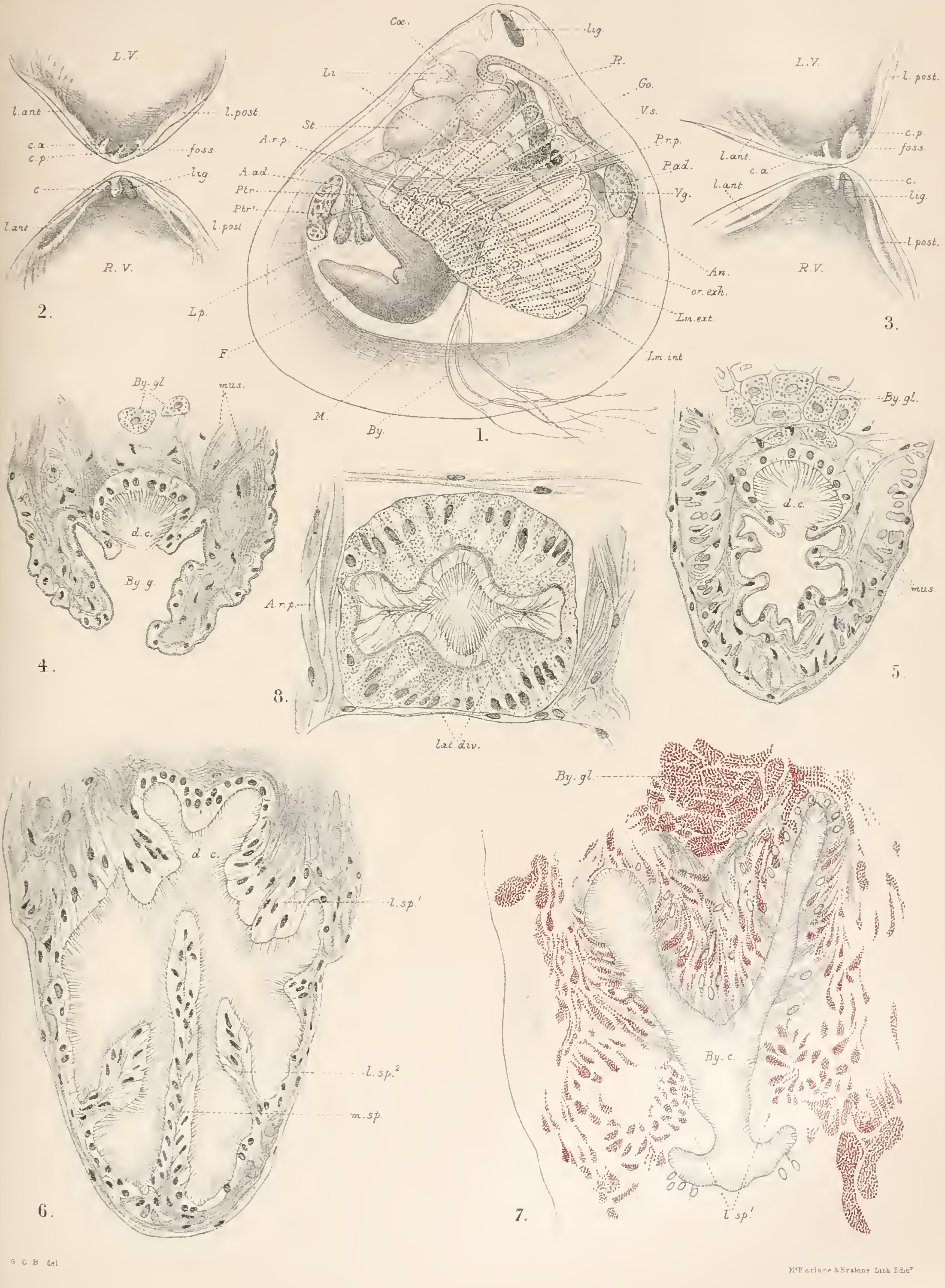
„ 24. A horizontal section through the gonaducts, vesiculæ seminales, and posterior part of the kidney of *J. heteropsammiæ*. Zeiss' $\frac{1}{12}$ hom. imm. Comp. Oc. 4. *Con.*, renal concretions.

„ 25. A section somewhat lower down from the same series as fig. 24, showing the renal duct, *Re.d.*, and the opening of the vesicula seminalis into the gonaduct; *br.*, attachment of branchial filament to the body-wall.

„ 26. A section next but one in the series to that shown in fig. 25, showing the renal (*Re.a.*) and genital (*Go.a.*) apertures.

„ 27. A young individual of *J. heterocyathi* with one growth lamella outside the prodissoconch, and with five gill fenestrations and the commencement of a sixth; *pr.diss.*, outline of the prodissoconch; *Card.a.*, anterior cardinal hinge tooth. × 150.

„ 28. A somewhat older individual of the same species with seven gill fenestrations and four growth lamellæ outside the prodissoconch. × 150.



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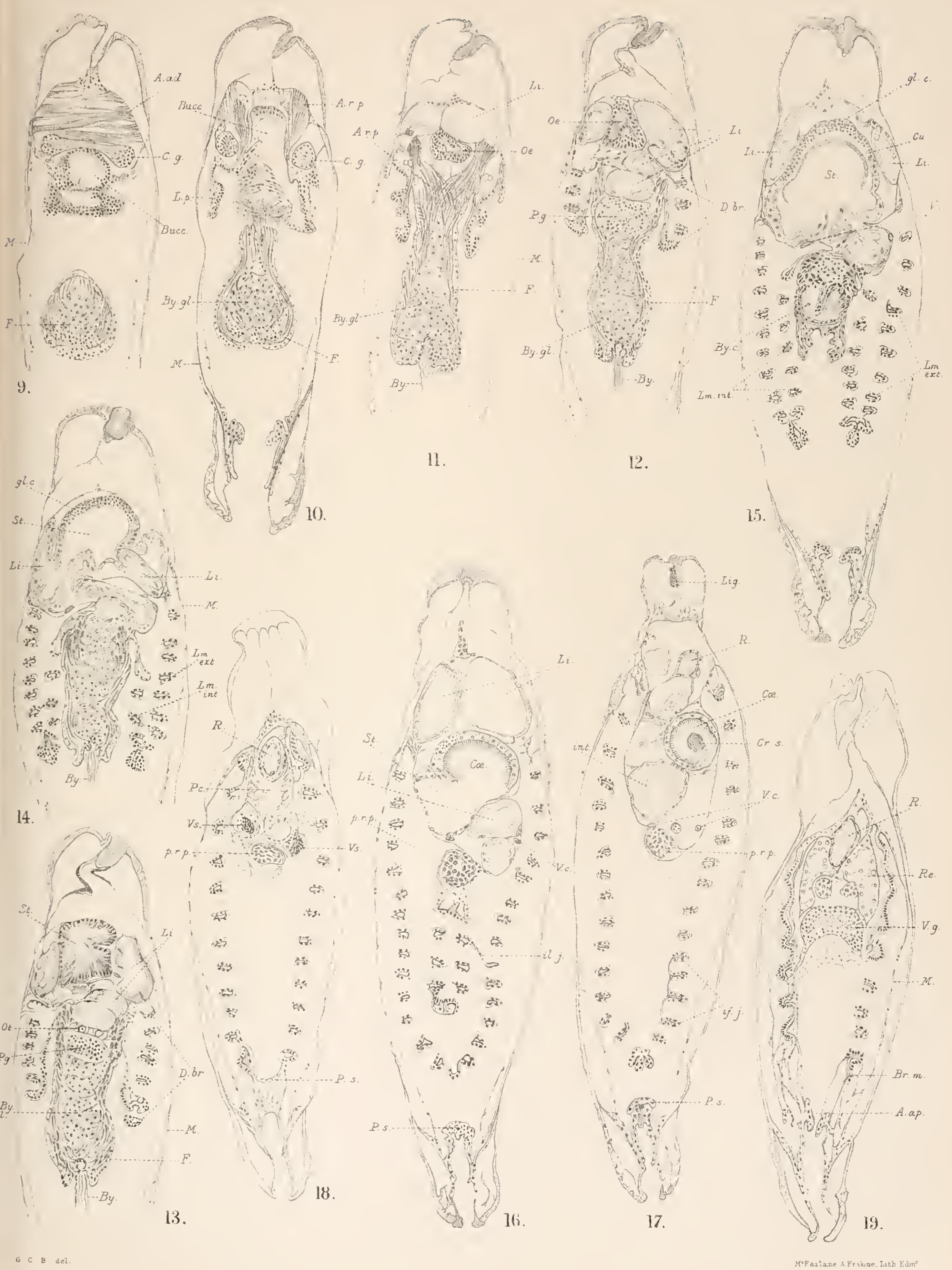
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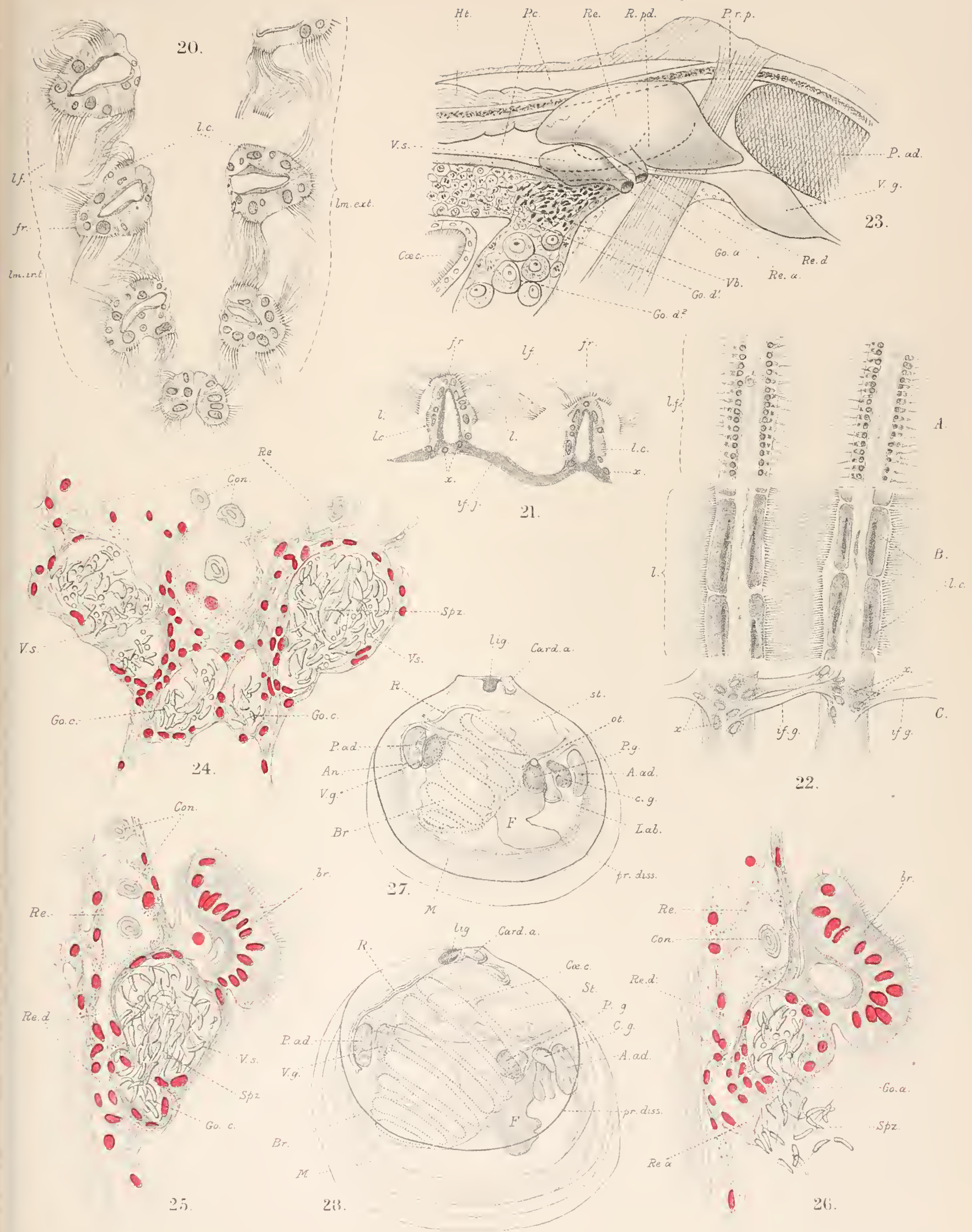
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REPORT

ON THE

MOLLUSCAN SHELLS

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

ROBERT STANDEN (ASSISTANT KEEPER, MANCHESTER MUSEUM), AND
ALFRED LEICESTER (LIVERPOOL),
MEMBERS OF THE CONCHOLOGICAL SOCIETY OF GREAT BRITAIN, AND IRELAND.

PROFESSOR HERDMAN has placed in our hands the collection of Mollusca* obtained during his dredgings around the coasts of Ceylon, and of these we have now identified 373 Gastropoda, 5 Scaphopoda, and 142 Pelecypoda. In addition we have still unidentified 1 *Eulima*, 1 *Marginella*, 1 *Amphiperas*, 2 *Rissoina*, 2 *Triforis*, 1 *Dentalium*, 2 *Cardium*, and a few bivalves which may possibly all prove new to science; also some juvenile forms of doubtful identity; and we much regret that the time at our disposal, for the compilation of this Catalogue, does not allow of their more critical examination. We propose at an early opportunity to investigate these "remainders," and hope to publish the results in the 'Journal of Conchology.'

The material chiefly consists of the larger-sized and well-known species, with a few of the smaller forms described in recent years by the numerous workers on the Molluscan Fauna of the Indo-Pacific region. The absence from Professor HERDMAN'S dredgings of the *minutiora* which have yielded such an abundance of new forms, mostly endemic, in other collections, is somewhat remarkable, and can only be accounted for on the supposition that the mesh of the dredge nets was too large to retain such small objects. The Pyramidellidæ, Rissoidæ, and the smaller Pleurotomidæ, &c., are barely represented, whilst such genera as *Scala*, *Litiopa*, *Tornatina*, *Cyclostrema* and *Bullia* do not occur at all in this collection, common as they have

* Separate Reports on the POLYPLACOPHORA, by Mr. E. R. SYKES, on the CEPHALOPODA, by Dr. W. E. HOYLE, and on the OPISTHOBRANCHIA, by Mr. G. P. FARRAN, have already appeared in this series. The present Report deals with the shells of the remaining Mollusca collected.—ED.

proved to be on the Indian coasts generally. The chief rarity worthy of note is *Mitra tankervillei*, hitherto a unique shell of unknown locality.

In the Catalogue we have quoted localities only, as found in the various jars and bottles, or as furnished by Professor HERDMAN. Particulars as to nature of bottom, and conditions under which the specimens were obtained, are so fully given under the several headings in the "Narrative" itself (Part I., p. 17) that we do not consider it necessary to repeat them.

We must thank Professor HERDMAN for the care bestowed in the collection and preservation of his specimens, and for his help in the general assortment of the material. Also we must record our deep indebtedness to Mr. EDGAR A. SMITH, F.Z.S., Mr. J. COSMO MELVILL, M.A., F.L.S., F.Z.S., and Mr. J. M. WILLIAMS and Mr. W. J. HALLS for much valuable assistance and for advice in the case of certain critical species.

In the classification adopted, we have followed the general sequence proposed by P. PELSENEER in his 'Introduction à l'étude des Mollusques' (1892), and have also referred often to P. FISCHER'S 'Manuel de Conchyliologie' (1887). For the characters of the species we have, to a certain extent, followed TRYON'S 'Manual of Mollusca,' at the same time allowing our own views fair latitude. We have considered it quite unnecessary in this instance to burden the Catalogue with the synonymy of each species, but have endeavoured in every case to give the name sanctioned by the laws of priority.

CATALOGUE OF SPECIES.

CLASS: CEPHALOPODA.

(In addition to the species of Cephalopoda recorded by Dr. HOYLE in his report, Part II., p. 185, the shell of *Spirula peroni*, LAMARCK, was obtained at Watering Point, Galle, and at Trincomalee.)

CLASS: GASTROPODA.

ORDER: PROSOBRANCHIATA.

FAMILY: PATELLIDÆ.

Helcioniscus testudinarius (LINN.).—S. of Modragam Paar.

FAMILY: FISSURELLIDÆ.

Fissurella tenuistriata, SOWERBY.—S. of Modragam Paar.

Glyphis salebrosa, REEVE.—Trincomalee.

Family: EMARGINULIDÆ.

Emarginula puncticulata, A. Adams.—Off Galle.

Macrochisma compressa, A. Adams.—S. of Modragam Paar.

Macrochisma scutiformis, Nevill.—S. of Modragam Paar.

Scutus corrugatus, Reeve.—Gulf of Manaar.

Scutus unguis (Linn.).—N. of Gulf of Manaar; off Galle; S. of Cheval Paar.

Family: HALIOTIDÆ.

Haliotis rufescens, Sowerby.—Gulf of Manaar.

Haliotis varia, Linn.—Trincomalee.

Family: STOMATELLIDÆ.

Stomatia phrymotis, Helb.—N. of Gulf of Manaar.

Gena lentricula, A. Adams.—Off Kaltura.

Family: DELPHINULIDÆ.

Delphinula formosa, Reeve.—N. of Gulf of Manaar.

Delphinula laciniata, Lamarck.—Gulf of Manaar, Modragam Paar.

Family: LIOTIIDÆ.

Liotia cidaris, Reeve.—S. of Cheval Paar; S. of Modragam Paar; Gulf of Manaar.

Family: TROCHIDÆ.

Trochus (Tectus) obeliscus, Gmelin.—Galle.

Trochus (Infundibulum) radiatus, Gmelin.—Pearl banks, Gulf of Manaar; off Aripu; off Galle; Trincomalee.

Trochus (Lamprostoma) sacellum, Philippi.—Off Galle.

Trochus (Lamprostoma) maculatus, Linn.—Gulf of Manaar; S. of Modragam Paar; Trincomalee.

Clanculus ceylanicus, Nevill.—Off Galle.

Clanculus depictus, A. Adams.—Trincomalee.

Clanculus microdon, A. Adams.—Palk Bay; S. of Modragam Paar.

Gibbula fanuloides, Fischer.—Palk Bay.

Gibbula pulcherrima, A. Adams.—Gulf of Manaar; off Aripu; off Galle.

Monilea callifera, Lamarck.—Gulf of Manaar.

Monilea callifera, var. **masoni**, Nevill.—Chilaw Paar.

Minolia gradata, Sowerby.—S. of Adam's Bridge.

Minolia variabilis, A. Adams.—Off Galle.

Solariella variabilis, A. Adams.—Pearl banks, Gulf of Manaar.

Calliostoma scobinata, A. Adams.—Jokkenpiddi Paar.

Calliostoma tranquebarica, Chemnitz.—From stomach of *Astropecten*, off Chilaw.

Euchelus asper, Gmelin (**Aradasia**, Gray).—S. of Modragam.

Euchelus atratus, Gmelin.—Pearl banks, Gulf of Manaar.

Euchelus proximus, A. Adams.—Gulf of Manaar; Palk Bay.

Euchelus pullatus, Anton.—Between Negombo and Chilaw.

Euchelus tricingulatus, A. Adams.—Gulf of Manaar.

Umbonium (Rotella) vestiarium, Linn.—Tampalakam Lake, Trincomalee.

Ethalia carneolata, Melvill.—Gulf of Manaar; off Galle; S. of Adam's Bridge.

Ethalia guamensis, Quoy.—N. of Gulf of Manaar.

Family: TURBINIDÆ.

Phasianella variegata, Lamarck.—Pearl banks, Gulf of Manaar; S. of Cheval Paar.

Phasianella variegata, var. **nivosa**, Reeve.—S. of Adam's Br.; Modragam; off Galle.

Turbo radiatus, Gmelin.—Pearl banks, Gulf of Manaar; S. end of Cheval Paar.

Turbo radiatus, var. **chemnitzianus**, Reeve.—Cheval Paar, Gulf of Manaar.

Turbo (Marmorostoma coronatus, Gmelin.—Trincomalee.

Turbo (Senectus) argyrostomus, Linn.—Welligam Bay.

Astralium stellatum, Gmelin.—S. of Adam's Bridge; Galle lagoon.

Family: NERITIDÆ.

Nerita (Thelicostyla) albicilla, Linn.—Galle.

Nerita polita, Linn.—Welligam Bay.

Nerita (Thelicostyla) chlorostoma, Lamarck.—Trincomalee.

Nerita (Pila) plicata, Linn.—Tampalakam Lake, Trincomalee.

Nerita (Odontostoma) rumphi, Recluz.—Galle.

Family: IANTHINIDÆ.

Ianthina fragilis, Lamarck.—Trincomalee.

Family: NATICIDÆ.

Natica ala-papilionis, Chemnitz.—Pearl banks, Gulf of Manaar; Tampalakam Lake, Trincomalee; off Galle.

Natica antoni, Philippi.—Tampalakam Lake, Trincomalee.

Natica dillwyni, Payr.—Palk Bay.

Natica euzona, Recluz.—Jokkenpiddi Paar; Tampalakam Lake, Trincomalee.

Natica queketti, Sowerby.—Pearl banks off Aripu, Gulf of Manaar.

Natica trailli, Reeve.—Off Galle.

Natica zanzibarica, Recluz.—Tampalakam Lake, Trincomalee.

Natica (Eunatica) tela-araneæ, Melvill.—Cheval Paar, Gulf of Manaar.

Natica (Mamma) albumen, Linn.—N. of Gulf of Manaar.

Natica (Mamma) candidissima, Leguil.—Gulf of Manaar; deep water off Galle.

Natica (Mamma) columnaris, Recluz.—Deep water off Galle.

Natica (Mamma) mamilla, Linn.—Trincomalee.

Natica (Mamilla) melanostoma, Gmelin.—S. of Adam's Bridge; Trincomalee.

Natica (Mamilla) simiæ, Deshayes.—Gulf of Manaar.

Sigaretus neritoideus, Linn.—Pearl banks, Gulf of Manaar.

Family: TRICHOTROPIDÆ.

Lippistes helicoides, Montfort (**Separatista chemnitzii**, A. Adams).—Donnan's Muttuvaratu Paar, Gulf of Manaar.

A fine specimen, with the animal. The exact position of this genus is not yet quite fixed, but it seems to have a certain amount of affinity with the Trichotropidæ.

Family: XENOPHORIDÆ.

Xenophora corrugata, Reeve.—Pearl banks, Gulf of Manaar; off Aripu; S. of Adam's Bridge; deep water off Galle; Trincomalee.

Xenophora indicus, Gmelin.—S.E. of Ceylon.

Family: CAPULIDÆ.

Crucibulum (Bicatillus) extinctorum, Lamarck.—Deep water off Galle; off Aripu.

Crucibulum (Bicatillus) morbidum, Reeve.—Pearl banks, Gulf of Manaar.

Crucibulum violaceum, Carpenter.—Off Cheval Paar.

Calyptræa layardi, Reeve.—S. of Adam's Bridge.

Calyptræa (Galerus) edgariana, Melvill.—Pearl banks, Gulf of Manaar; off Aripu; Trincomalee.

Crepidula (Siphopatella) walshi, Herm.—Gulf of Manaar.

Capulus lissus, E. A. Smith.—S. of Modragam Paar.

Amathina tricostata, Gmelin.—S. end of Cheval Paar.

Family: HIPPONYCIDÆ.

Mitrularia equestris, Linn.—Gulf of Manaar.

Family: SOLARIIDÆ.

Solarium lævigatum, Lamarck.—Deep water off Galle.

Solarium impressum, Nevill.—Trincomalee.

Solarium modestum, Philippi.—Pearl banks off Aripu, Gulf of Manaar.

Solarium perspectivum, Linn.—Trincomalee.

Solarium (Torinia) variegatum, Gmelin.—Gulf of Manaar.

Family: LITTORINIDÆ.

Littorina scabra, Linn.—Backwater, Manaar Island.

Family: CERITHIIDÆ.

Cerithium armatum, Phil.—Trincomalee ; Periya Paar.

Cerithium citrinum, Sowerby.—Pearl banks, Gulf of Manaar.

Cerithium morus, Lamarck.—Deep water off Galle.

Cerithium tuberosum, Fabricius.—Off Mutwal Island.

Cerithium yerburyi, E. A. Smith.—S. of Adam's Bridge.

Cerithium (Vertagus) aluco, Linn.—S. of Modragam Paar.

Cerithium (Vertagus) articulatum, Adams and Reeve.—N. of Gulf of Manaar.

Cerithium (Vertagus) fasciatum, Brug., var. **martinianum**, Pfr.—Backwater, Manaar Island ; Galle ; S. of Modragam Paar.

Cerithium (Vertagus) kochi, Phil.—Pearl banks off Aripu, Gulf of Manaar; Trincomalee ; Modragam Paar ; Galle.

Cerithium (Vertagus) obeliscus, Brug.—Backwater, Manaar Island ; off Galle.

Colina selecta, Melvill and Standen.—Galle.

Potamides (Tympanotonus) fluviatilis, Pot. and Mich.—Muddy Creek, N. of Manaar Island.

Potamides (Telescopium) fuscum, Schumacher.—Trincomalee.

Pyrazus palustris, Linn.—Pearl bank off Aripu ; Trincomalee.

Family: PLANAXIDÆ.

Planaxis sulcatus, Born.—Deep water off Galle ; Trincomalee.

Family: TURRITELLIDÆ.

Turritella carinifera, Lamarck.—Trincomalee.

Turritella triplicata, Studer.—Trincomalee.

Turritella (Haustator) candida, Reeve.—S. of Adam's Bridge.

Turritella (Haustator) columnaris, Kiener.—Deep water off Galle.

Turritella (Haustator) maculata, Reeve.—S. of Adam's Bridge; Trincomalee.

Turritella (Zaria) duplicata, Linn.—S.E. of Ceylon; Welligam Bay; Trincomalee; N. of Gulf of Manaar.

Turritella (Eglisia) vittulata, Adams and Reeve.—N. of Gulf of Manaar.

Family: VERMETIDÆ.

Vermetus (Thylacodes) dentiferus, Lamarck.—Gulf of Manaar.

Siliquaria cumingi, Mörch.—S. of Modragam Paar.

Siliquaria tostus, Mörch.—S.E. of Ceylon; S. of Modragam Paar.

Family: STROMBIDÆ.

Strombus papilio, Chemnitz.—N. of Gulf of Manaar.

Strombus (Gallinula) isabella, Lamarck.—Trincomalee.

Strombus (Gallinula) marginatus, Linn.—N. of Gulf of Manaar; Trincomalee.

Strombus (Gallinula) succinctus, Linn.—Pearl banks off Aripu, Gulf of Manaar; S. of Adam's Bridge; off Mutwal Island; Trincomalee.

Strombus (Canarium) canarium, Linn.—Gulf of Manaar; Trincomalee.

Strombus (Canarium) elegans, Sowerby.—Pearl banks off Aripu, Gulf of Manaar; deep water off Galle; Modragam Paar; S. of Adam's Bridge.

Strombus (Canarium) floridus, Lamarck.—Trincomalee.

Strombus (Canarium) gibberulus, Linn.—Gulf of Manaar; Trincomalee.

Strombus (Canarium) pulchellus, Reeve.—N. of Gulf of Manaar; pearl bank, Aripu; S. of Adam's Bridge; Donnan's Paar; Trincomalee; deep water off Galle.

Strombus (Canarium) samarensis, Reeve.—N. of Gulf of Manaar.

Strombus (Canarium) urceus, Linn.—Pearl banks, Gulf of Manaar; Trincomalee.

Strombus (Canarium) yerburyi, E. A. Smith.—N. of Gulf of Manaar; S. of Adam's Bridge; deep water off Galle; pearl banks off Aripu; Trincomalee.

Strombus (Monodactylus) auris-dianæ, Linn.—N. of Gulf of Manaar; off Aripu.

Strombus (Monodactylus) gallus, LINN.—Modragam Paar.

Pterocera lambis, LINN.—Trincomalee.

Pterocera (Millepes) scorpio, LINN.—S. of Modragam Paar.

Rostellaria (Rimula) crispata, SOWERBY.—Pearl banks, Gulf of Manaar; Trincomalee; S.E. of Ceylon; S. of Modragam Paar.

Seraphs terebellum, MONTFORT.—Pearl banks, Gulf of Manaar; S.E. of Ceylon; S. of Modragam Paar; Trincomalee.

FAMILY: CYPRÆIDÆ.

Cypræa arabica, LINN.—Gulf of Manaar; Tampalakam Lake; Trincomalee.

Cypræa caput-serpentis, LINN.—Welligam Bay; Trincomalee.

Cypræa clandestina, LINN.—Pearl banks, Gulf of Manaar; Donnan's Paar; Palk Bay; deep water off Galle; Trincomalee.

Cypræa coffea (SOWERBY).—Trincomalee.

Cypræa caurica, LINN.—Gulf of Manaar. One typical example.

Cypræa caurica, LINN., var. **cairnsiana**, MELVILL and STANDEN ('Jour. of Conch.,' vol. xi., 1904, p. 118).—S. of Adam's Bridge; Modragam Paar; S. end of Cheval Paar; Trincomalee.

This beautiful form bears precisely the same relation to typical *caurica* that *coloba*, MELVILL (= *greegori*, FORD) does to *cruenta*, GMELIN. The Ceylonese examples are quite as fine, but slightly smaller, than the Karachi ones, and far surpass in coloration others of this same variety from Borneo and the East Indies.

Cypræa erosa, LINN., var. **straminea**, MELVILL.—S. of Modragam Paar.

Cypræa errones, LINN.—Trincomalee.

Cypræa fimbriata, GMELIN.—Gulf of Manaar.

Cypræa gangrenosa (SOLANDER), var. **melanosema**, MELVILL.—Gulf of Manaar; Modragam Paar; off Galle.

Cypræa lutea (GRONOV.).—Gulf of Manaar.

Cypræa lynx, LINN.—Trincomalee.

Cypræa moneta (LINN.).—Tampalakam; Trincomalee; Galle; S. of Modragam.

Cypræa neglecta, SOWERBY.—Gulf of Manaar; Trincomalee.

Cypræa ocellata (Linn).—S. of Adam's Bridge; Donnan's Paar; S. end of Cheval Paar; off Galle; Trincomalee; S. of Modragam Paar; off Aripu.

Cypræa onyx (Linn.), var. **adusta** (Chemnitz).—Pearl banks, Gulf of Manaar.

Cypræa tigris, Linn.—Gulf of Manaar.

Cypræa vitellus, Linn.—S. of Modragam Paar; Trincomalee.

Cypræa ziczac, Linn.—S. of Adam's Bridge.

Trivia annulata, Gray.—S. of Adam's Bridge.

Trivia brevissima (Sowerby).—Deep water off Galle.

Trivia cicercula (Linn).—Trincomalee.

Trivia globosa (Gray).—From stomach of *Astropecten*, off Chilaw, 10 fathoms.

Trivia nucleus, Linn.—Gulf of Manaar; Trincomalee.

Trivia fibula, Kiener.—Two "live" examples from Gulf of Manaar. We quite agree with Mr. J. M. Williams, to whom we submitted these specimens, that they are not the same as *Trivia globosa* (Gray).

Trivia rubinicolor (Gaskoin).—S. of Adam's Bridge. A dead shell, more like a fossil, as recently-dead *Triviæ* are invariably glossy or polished, but Mr. Williams identifies it without any doubt as this species.

Trivia staphylæa (Linn.).—S. of Adam's Bridge; Trincomalee.

Trivia staphylæa, var. **limacina**, Lamarck.—S. of Modragam Paar.

Ovula (Volva) volva, Linn.—Pearl banks, Gulf of Manaar.

Amphiperas pyriformis, Sowerby.—S. of Modragam Paar.

Family: DOLIIDÆ.

Dolium maculatum, Lamarck.—Gulf of Manaar; Trincomalee.

Dolium olearium, Bruguière.—Gulf of Manaar; Trincomalee.

Family: CASSIDIDÆ.

Cassis canaliculata, Lamarck.—N. of Gulf of Manaar; S.E. of Ceylon.

Cassis (Casmaria) vibex, H. and A. Adams.—S. of Adam's Bridge; off Galle.

Cassis (Phalium) glauca, Linn.—Pearl banks, Gulf of Manaar.

Pyrula ficus, Lamarck (**P. lævigata**, Reeve).—Trincomalee ; off Aripu.

Pyrula reticulata, Lamarck.—Gulf of Manaar ; off Galle ; Trincomalee.

Family : TRITONIIDÆ.

Lotorium canaliferus, Lamarck (**Triton**, Montfort).—Trincomalee.

Lotorium lotorium, Linn.—Pearl banks off Aripu, Gulf of Manaar ; S.E. of Ceylon ; S. of Adam's Bridge.

Lotorium olearium (Linn.).—Off Aripu, Gulf of Manaar.

Lotorium tripus, Chemnitz.—Trincomalee.

Lotorium (Simpulum) chlorostomum (Lamarck).—Galle.

Lotorium (Simpulum) labiosum (Wood).—Deep water off Galle ; S. of Cheval Paar.

Lotorium (Simpulum) pileare (Linn.).—Pearl banks, Gulf of Manaar ; Trincomalee.

Lotorium (Simpulum) rubecula, Linn.—Pearl banks, Gulf of Manaar.

Lotorium (Gutturnium) cynocephalus (Lamarck).—Galle.

Lotorium (Gutturnium) exilis, Reeve.—Pearl banks, Gulf of Manaar.

Lotorium (Gutturnium) gallinago, Reeve.—Trincomalee.

Lotorium (Gutturnium) retusum (Lamarck).—Pearl banks, Gulf of Manaar.

Lotorium (Gutturnium) tuberosum (Lamarck).—Galle.

Lotorium (Gutturnium) vespaceum (Lamarck).—Pearl banks, Gulf of Manaar ; S. of Modragam Paar.

Lotorium (Lagena) cingulatum (Pfr.).—Off Aripu, Gulf of Manaar ; off Galle.

Lotorium (Epidromus) testaceum (Mörch).—Cheval Paar ; S. of Adam's Bridge ; pearl banks, Gulf of Manaar.

Gyrineum crumena (Lamarck).—Palk Bay ; pearl banks off Aripu, Gulf of Manaar ; off Kaltura.

Gyrineum (Bursa) albivaricosum, Reeve.—Gulf of Manaar ; S. of Adam's Bridge.

Gyrineum (Lampas) bufonia, Gmelin.—Pearl banks, Gulf of Manaar.

Gyrineum (Lampas) graniferum, Lamarck.—Pearl banks off Aripu, Gulf of Manaar ; S. end of Cheval Paar ; S. of Modragam Paar ; Trincomalee.

Gyrineum (Argobuccinum) bituberculare (REEVE).—Pearl banks off Aripu, Gulf of Manaar; off Mutwal Island; S. of Modragam Paar; S. of Adam's Bridge; deep water off Galle; off Mount Lavinia; Trincomalee.

Gyrineum (Argobuccinum) margaritula, DESHAYES.—Pearl banks, Gulf of Manaar; deep water off Galle.

Gyrineum (Argobuccinum) pusillum, BRODERIP.—S. of Adam's Bridge; Donnan's Paar; S. of Modragam Paar.

Gyrineum (Argobuccinum) tuberculatum, BRODERIP.—Pearl banks, Gulf of Manaar.

Distorsio cancellinus, ROISSY.—N. of Gulf of Manaar; Trincomalee.

Distorsio cancellinus, var. **decipiens,** REEVE.—Deep water off Galle.

Distorsio ridens, REEVE.—Pearl banks off Aripu.

FAMILY: PYRAMIDELLIDÆ.

Pyramidella acus, GMELIN.—Trincomalee.

FAMILY: CORALLIOPHILIDÆ.

Coralliophila violacea, KIENER.—Donnan's Paar.

FAMILY: MURICIDÆ.

Murex malabaricus, E. A. SMITH.—Gulf of Manaar.

Murex nigrispinosus, REEVE.—Deep water off Galle.

Murex ramosus, LINN.—Palk Bay; N. of Gulf of Manaar.

Murex rectirostris, SOWERBY.—Deep water off Galle.

Murex tenuispina, LAMARCK.—Deep water off Galle.

Murex ternispina, LAMARCK.—N. of Gulf of Manaar; Palk Bay; off Galle.

Murex (Chicoreus) aculeatus, LAMARCK.—N. of Gulf of Manaar; off Galle.

Murex (Chicoreus) adustus, LAMARCK.—N. of Gulf of Manaar.

Murex (Chicoreus) adustus, var. **huttoniæ,** WRIGHT.—Off Aripu, Gulf of Manaar.

Murex (Chicoreus) palmiferus, SOWERBY.—Deep water off Galle; Gulf of Manaar; S. of Modragam Paar.

Murex (Chicoreus) sauliæ, Sowerby.—Deep water off Galle.

Murex (Phyllonotus) anguliferus, Lamarck.—Gulf of Manaar; Periya Paar.

Murex (Pteronotus) pinnatus, Wood.—Pearl banks off Aripu, Gulf of Manaar; S. of Modragam Paar.

Murex (Homalacantha) varicosus, Sowerby.—Donnan's Paar.

Murex (Haustellum) haustellum, Linn.—N. of Gulf of Manaar; Galle; Palk Bay; deep water off Galle; Trincomalee.

Urosalpinx contracta, Reeve.—Palk Bay.

Urosalpinx innotabilis, E. A. Smith.—Galle; S. of Adam's Bridge.

Rapana bulbosa, Solander.—N. of Gulf of Manaar.

Latiaxis diadema, Sowerby.—Off Galle.

Purpura coronata, Lamarck.—Backwater, Manaar Island.

Purpura persica, Linn.—Welligam Bay.

Purpura (Thalessa) hippocastanum, Lamarck.—Galle.

Purpura (Stramonita) bufo, Lamarck.—Welligam Bay.

Purpura (Polytropa) sacellum, Chemnitz.—Pearl banks, Gulf of Manaar.

Pinaxia coronata, A. Adams.—Pearl banks off Aripu, Gulf of Manaar; S. of Adam's Bridge; Modragam Paar; Jokkenpiddi Paar; S. end of Cheval Paar.

Cuma carinifera (Lamarck).—Tampalakam Lake, Trincomalee.

Ricinula horrida, Lamarck.—Off Galle.

Sistrum elongatum, Blainville.—N. of Gulf of Manaar.

Sistrum chrysostoma, Deshayes.—Gulf of Manaar.

Sistrum konkanense, Melvill.—Gulf of Manaar.

Sistrum spectrum, Reeve.—Pearl banks, Gulf of Manaar; Aripu Reef; Trincomalee; S. end of Cheval Paar; S. of Adam's Bridge; Jokkenpiddi Paar; off Chilaw, 10 fathoms; off Mutwal Island; S. of Modragam Paar.

Sistrum tuberculatum, Blainville.—N. of Gulf of Manaar.

Family: COLUMBELLIDÆ.

Columbella propinquans, E. A. Smith.—Jokkenpiddi Paar; Trincomalee; S. of Adam's Bridge; Donnan's Paar.

Columbella (Pygmæa) flavida, Lamarck.—Gulf of Manaar; Jokkenpiddi Paar; off Mutwal Island.

Columbella (Pygmæa) pardalina, Lamarck.—S. of Modragam Paar; pearl banks, Gulf of Manaar.

Columbella (Pygmæa) turturina, Lamarck.—Cheval Paar; Donnan's Paar; S. of Modragam Paar.

Columbella (Pygmæa) tyleri, Gray.—S. of Modragam Paar.

Columbella (Pygmæa) versicolor, Sowerby.—Off Galle.

Columbella (Conidea) flava, Brug.—Pearl banks, Gulf of Manaar; Cheval Paar.

Family: NASSIDÆ.

Nassa arcularia, Linn.—Trincomalee.

Nassa nevilliana, Preston.—Trincomalee.

Nassa pulla, Linn.—Pearl banks, Gulf of Manaar; S. of Adam's Bridge.

Nassa (Arcularia) thersites, Brug.—Tampalakam Lake, Trincomalee.

Nassa (Tritia) crenulata, Brug.—Welligam Bay.

Nassa (Alectryon) elegans, Kiener.—Gulf of Manaar; Trincomalee.

Nassa (Alectryon) glans, Linn.—Pearl banks, Gulf of Manaar.

Nassa (Zeuxis) pallidula, A. Adams.—Deep water off Galle.

Nassa (Niotha) gemmulata, Lamarck.—Pearl banks, Gulf of Manaar; off Kaltura; deep water off Galle; S. of Modragam Paar.

Nassa (Niotha) marginulata, Lamarck.—Trincomalee.

Nassa (Niotha) splendidula, Dunker.—Pearl banks, Gulf of Manaar.

Nassa (Niotha) stigmaria, A. Adams.—Pearl banks, Gulf of Manaar; S. of Adam's Bridge; deep water off Galle.

Nassa (Hima) frederici, MELVILL and STANDEN.—Gulf of Manaar; Trincomalee.

This is **Nassa (Hima) townsendi**, MELV., 'Mem. Manch. Soc.,' vol. xli., part iii. (1897), No. 7, p. 4, plate 6, fig. 1 (*non* DALL).

Cyllene grayi, REEVE.—S. of Adam's Bridge; Chilaw Paar; from stomach of *Astropecten* off Chilaw, 10 fathoms.

FAMILY: BUCCINIDÆ.

Pisania ignea, GMELIN.—Deep water off Galle; S. of Modragam.

Pisania marmorata, REEVE.—Gulf of Manaar.

Pisania picta, REEVE.—N. of Gulf of Manaar.

Tritonidea melanostoma, SOWERBY.—Pearl bank, Aripu; N. of Gulf of Manaar; S. of Modragam Paar.

Tritonidea rubiginosa (REEVE).—Galle.

Tritonidea tissoti, PETIT.—Off Galle.

Tritonidea tranquebarica, GMELIN.—Gulf of Manaar.

Tritonidea undosa, LINN.—Pearl banks off Aripu; Trincomalee.

Engina zea, MELVILL.—N. end of Manaar.

Nassaria acuminata, REEVE.—Pearl banks, Gulf of Manaar.

Nassaria nivea, GMELIN.—Palk Bay; S. of Adams' Bridge.

Nassaria suturalis, A. ADAMS.—Pearl banks off Aripu, Gulf of Manaar; S. of Adam's Bridge; deep water off Galle; Palk Bay; S. of Modragam Paar.

Phos blainvillei, DESHAYES.—Trincomalee.

Phos nodicostatus, A. ADAMS.—Gulf of Manaar; S. of Modragam Paar.

Phos retecosus, HINDS.—Gulf of Manaar.

Phos roseatus, HINDS.—Gulf of Manaar; deep water off Galle; Palk Bay; S. of Adam's Bridge.

Latrunculus spirata, LAMARCK (**Eburna**, LAM.).—Deep water off Galle; Welligam.

Latrunculus zeylanicus, BRUG.—Pearl banks, Gulf of Manaar.

FAMILY: TURBINELLIDÆ.

Turbinella pyrum, LINN. (**Turbinella rapa**, GMELIN.).—Pearl banks off Aripu, Gulf of Manaar; deep water off Galle; Trincomalee.

The "Chank" occurs in the collection from its egg-capsules, through all stages of growth, to the large and swollen spotless form distinguished by most authors as *T. rapa*, GMEL., = *gravis*, DILLW., = *clavata*, WAGN., = *napus*, LAM.; but the distinction does not hold good, the shell becoming more swollen and less spotted with increase in size.

Vasum turbinellum, LINN.—Trincomalee.

Tudicla spirillus, LINN.—Pearl banks, Gulf of Manaar; off Mutwal Island; Palk Bay; deep water off Galle; Trincomalee.

Melongena vespertilio, LAMARCK.—Gulf of Manaar.

FAMILY: FASCIOLARIIDÆ.

Fusus colus, LINN.—Pearl banks, Gulf of Manaar; Trincomalee.

Fasciolaria filamentosa, MARTYN.—Pearl banks, Gulf of Manaar; Galle.

Fasciolaria trapezium (LINN.).—N. of Gulf of Manaar; Trincomalee.

Latirus lancea, GMELIN.—Gulf of Manaar.

Latirus (Peristernia) pagodiformis, MELVILL.—Gulf of Manaar.

Latirus (Peristernia) pulchellus, REEVE.—Pearl banks, Gulf of Manaar; S. end of Cheval Paar; S. of Adam's Bridge.

Latirus (Peristernia) turritus, GMELIN.—Gulf of Manaar; Trincomalee; Mudalaikuli Paar; S. of Modragam Paar.

Latirus (Plicatella) polygonus, GMELIN.—S. end of Cheval Paar.

FAMILY: MITRIDÆ.

Mitra guttata, SWAINSON.—N. of Gulf of Manaar.

Mitra versicolor, MARTYN.—Gulf of Manaar.

Mitra (Scabricola) crenifera, LAMARCK.—Off Galle; Aripu; S. of Modragam Paar.

Mitra (Scabricola) antoniæ, H. ADAMS.—Gulf of Manaar; Trincomalee.

Mitra (Scabricola) scabriuscula, LAMARCK.—Pearl banks, Gulf of Manaar.

Mitra (Cancilla) insculpta, Reeve.—Off Galle; Trincomalee.

Mitra (Cancilla) interlirata, Reeve.—Pearl banks, Gulf of Manaar.

Mitra (Turricula) melongena, Lamarck.—S. of Modragam Paar.

Mitra (Costellaria) acupicta, Reeve.—Trincomalee.

Mitra (Costellaria) exasperata, Gmelin.—S. of Adam's Bridge.

Mitra (Costellaria) clathrata, Reeve.—Gulf of Manaar.

Mitra (Costellaria) crebrilirata, Reeve.—N. of Gulf of Manaar; Trincomalee.

Mitra (Costellaria) militaris, Reeve, var. **antonelli**, Dohrn.—Gulf of Manaar.

Mitra (Costellaria) mucronata, Swainson.—Gulf of Manaar.

Mitra (Costellaria) modesta, Reeve.—Gulf of Manaar; S. of Adam's Bridge; deep water off Galle; S. end of Cheval Paar.

Mitra (Costellaria) revelata, Melvill.—Gulf of Manaar; S. of Modragam Paar.

Mitra (Costellaria) tankervillei, Melvill,* **Mitra rugosa**, Swain.—Deep water off Galle.

Hitherto this species has been unique in the collection of Mr. J. Cosmo Melvill, and was obtained by him from the collection of the late Dr. Prevost, of Alençon, who had acquired it from the Norris collection. This last collection was celebrated for its *Mitræ*, and this was one of its most particular rarities. The figures given by both Reeve and Sowerby are, of course, taken from this specimen when it was in the celebrated collection of shells belonging to the Earl of Tankerville, dispersed in 1825. Professor Herdman's specimen is in a dead condition, and unfortunately has the apex broken, otherwise it exactly harmonises with the type. This is a most interesting discovery, establishing Ceylon as the locality for this rare shell.

Mitra (Costellaria) zebuensis, Reeve.—S. of Adam's Bridge.

Mitra (Pusia) osidiris, Issel.—S. of Modragam Paar.

Mitra (Swainsonia) fissurata, Lamarck.—S.E. of Ceylon; S. of Modragam Paar.

Family: HARPIDÆ.

Harpa conoidalis, Lamarck.—Trincomalee.

Harpa minor, Rumphius.—Tampalakam Lake, Trincomalee.

* 'Journal of Conchology,' vol. v., p. 332.

Harpa nobilis, Rumphius.—Trincomalee.

Harpa ventricosa, Lamarck.—N. of Negombo, 9 fathoms.

Family: MARGINELLIDÆ.

Marginella (Cryptospira) angustata, Sowerby.—Pearl banks, Gulf of Manaar; deep water off Galle; S. of Adam's Bridge; Palk Bay; Chilaw Paar; S. of Modragam Paar; Trincomalee; off Aripu; off Mutwal Island.

This species seems to show considerable variation; in several localities specimens of a very beautiful golden brown colour occur.

Marginella (Cryptospira) mabellæ, Melvill and Standen.*—Pearl banks off Manaar; S. of Adam's Bridge.

In form this is distinct from any near ally, but most recalls the West Indian *M. oblonga*, Sowb. It is gracefully oblong, very shining, straw-coloured, with white shining callous deposit over the columellar region and outer lip; the dorsal margin thick, with straw-coloured callus; mouth narrow, columella four-plaited.

Family: OLIVIDÆ.

Oliva (Strephona) caroliniana, Duclos.—Off Galle.

Oliva (Strephona) elegans, Lamarck.—Trincomalee.

Oliva (Strephona) irisans, Lamarck.—Trincomalee.

Oliva (Strephona) ispidula, Lamarck.—Trincomalee; S. of Adam's Bridge.

Oliva (Strephona) lepida, Duclos.—Pearl banks off Aripu, Gulf of Manaar; Galle; S. of Modragam Paar. Many beautiful colour varieties.

Oliva (Strephona) polita, Marratt.—Gulf of Manaar.

Oliva (Strephona) mantichora, Duclos.—Gulf of Manaar; Modragam Paar.

Oliva (Strephona) maura, Lamarck.—Trincomalee.

Oliva (Strephona) pacifica, Marratt.—Pearl banks off Aripu.

A dark variety, interesting as being from a new locality.

Oliva (Strephona) picta, Reeve.—Gulf of Manaar; S. of Modragam Paar.

Oliva (Strephona) reticularis, Lamarck.—Pearl banks off Aripu.

Oliva (Strephona) tremulina, Lamarck.—Pearl banks off Aripu; off Galle.

* "Moll. Pers. Gulf," 'Proc. Zool. Soc.,' 1901, p. 452, pl. xxiii., fig. 20.

Oliva (Agaronia) nebulosa, LAMARCK.—Welligam; Modragam Paar; Trincomalee.

Olivancillaria gibbosa, BORN.—Trincomalee; S. of Modragam; Aripu; off Galle.

Ancilla ampla, GMELIN.—Gulf of Manaar; S. of Modragam Paar; Trincomalee.

Ancilla albisulcata, GMELIN.—N. of Gulf of Manaar.

Ancilla cinnamomea, LAMARCK.—Gulf of Manaar; S. of Adam's Bridge.

Ancilla fasciata, REEVE.—S. of Adam's Bridge.

Ancilla tindalli, MELVILL.—Deep water off Galle; Cheval Paar; S. of Adam's Bridge; pearl banks, Gulf of Manaar; S. of Modragam Paar.

FAMILY: TEREBRIDÆ.

Terebra duplicata, LINN.—Pearl banks off Aripu, Gulf of Manaar; Jokkenpiddi Paar; S. of Adam's Bridge; deep water off Galle.

Terebra straminea, GRAY.—Off Galle; off Kaltura and Mount Lavinia.

Terebra triseriata, GRAY.—Off Galle; Trincomalee.

Terebra (Subula) crenulata, LINN.—Tampalakam; deep water off Galle.

Terebra (Subula) hastata, GMELIN.—Pearl banks, Gulf of Manaar; Palk Bay.

Terebra (Hastula) strigilata, LINN.—S. of Adam's Bridge.

FAMILY: CONIDÆ.

Conus marmoreus, LINN.—S.W. of Negombo, 20 fathoms.

Conus (Stephanoconus) lividus, BRUG.—Off Aripu; S. of Adam's Bridge.

Conus (Puncticulis) obesus, HWASS. (**Conus ceylonicus**, CHEMNITZ).—Pearl banks off Aripu, Gulf of Manaar; S. of Modragam Paar.

Conus (Dendroconus) figulinus, LINN.—S.E. of Ceylon.

Conus (Lithoconus) augur, BRUG.—Off Aripu; Modragam Paar; off Galle.

Conus (Lithoconus) literatus, LINN.—Deep water outside banks, Gulf of Manaar; S. of Modragam Paar.

Conus (Lithoconus) tesselatus, BRUG.—N. of Gulf of Manaar; S. of Modragam Paar; Trincomalee.

Conus (Lithoconus) vitulinus, Brug.—Pearl banks off Aripu; Trincomalee.

Conus (Leptoconus) elegans, Sowerby.—Modragam Paar; off Aripu; Palk Bay.

Conus (Leptoconus) lentiginosus, Reeve.—Pearl bank, Aripu.

Conus (Leptoconus) longurionis, Kiener.—Off Galle.

Conus (Leptoconus) planiliratus, Sowerby.—Pearl banks off Aripu, Gulf of Manaar; deep water off Galle.

Conus (Rhizoconus) generalis, Linn.—Pearl banks off Aripu, Gulf of Manaar; S. of Adam's Bridge; deep water off Galle.

Conus (Rhizoconus) lithoglyphus, Meusch.—Deep water off Galle.

Conus (Rhizoconus) maldivus, Linn.—Modragam Paar.

Conus (Rhizoconus) miles, Linn.—Modragam Paar; Trincomalee.

Conus (Rhizoconus) monile, Linn.—N. of Gulf of Manaar; Trincomalee; S. of Modragam Paar.

Conus (Rhizoconus) virgo, Linn.—Trincomalee.

Conus (Chelyconus) amabilis, Lamarck.—Off Aripu.

Conus (Chelyconus) catus, Brug.—Modragam Paar.

Conus (Chelyconus) lignarius, Reeve.—Gulf of Manaar.

Conus (Chelyconus) nimbosus, Brug.—Pearl banks off Aripu; Modragam Paar.

Conus (Nubecula) striatus, Linn.—Off Aripu, Gulf of Manaar; Trincomalee.

Conus (Nubecula) termineus, Lamarck.—Trincomalee.

Conus (Cylinder) amadis, Chemnitz.—Pearl bank, Aripu; Modragam Paar.

Pleurotoma crispa, Lamarck.—S. of Adam's Bridge.

Pleurotoma marmorata, Lamarck.—S. of Adam's Bridge.

Pleurotoma tigrina, Lamarck.—N. of Gulf of Manaar; off Galle; Trincomalee.

Pleurotoma (Turris) undosa, Lamarck.—Pearl banks off Manaar.

Pleurotoma (Gemmula) carinata, Gray.—Off Mutwal Island.

Pleurotoma (Oligotoma) violacea, Hinds.—S. of Modragam Paar.

Surcula cingulifera, LAMARCK.—S.E. Ceylon.

Surcula javana, LINN. (= **nodifera**, LAMARCK).—Galle.

Drillia crenularis, LAMARCK.—Pearl banks, Gulf of Manaar; S. of Modragam.

Drillia spectrum, REEVE.—Deep water off Galle.

Cythara hypercalles, MELVILL.—N. of Shoal Buoy.

FAMILY: CANCELLARIIDÆ.

Cancellaria (Trigonostoma) articularis, SOWERBY.—Jokkenpiddi Paar.

Cancellaria (Trigonostoma) crenifera, SOWERBY.—Pearl banks, Gulf of Manaar.

Cancellaria (Trigonostoma) hystrix, REEVE.—S. of Adam's Bridge.

Cancellaria (Trigonostoma) lamellosa, HINDS.—Pearl banks, Gulf of Manaar.

ORDER: OPISTHOBRANCHIATA.*

FAMILY: ACTEONIDÆ.

Solidula affinis, A. ADAMS.—Pearl bank, Aripu; Trincomalee; off Galle.

FAMILY: SCAPHANDRIDÆ.

Atys naucum, LINN.—Trincomalee.

FAMILY: BULLIDÆ.

Bulla ampulla, LINN.—Pearl banks, Gulf of Manaar; Trincomalee; S. of Adam's Bridge; pearl banks off Aripu; deep water off Galle; Trincomalee; S. of Modragam.

FAMILY: APLUSTRIDÆ.

Aplustrum thalassiarchi, MARTYN.—S. of Modragam Paar.

FAMILY: RINGICULIDÆ.

Ringicula encarpoferens, FOLIN.—Galle.

CLASS: SCAPHOPODA.

FAMILY: DENTALIIDÆ.

Dentalium attenuatum, SOWERBY.—Off Galle.

* See also Mr. FARRAN'S Report, Part III., p. 329.—Ed.

Dentalium eburneum, LINN.—Palk Bay.

Dentalium formosum, ADAMS and REEVE.—Off N. end of Manaar Island; S. of Adam's Bridge.

Dentalium octogonum, LAMARCK.—Gulf of Manaar; S. of Adam's Bridge; Palk Bay; Trincomalee; Welligam Bay.

Dentalium subtorquatum, FISCHER.—S. of Adam's Bridge.

CLASS: PELECYPODA.

FAMILY: OSTREIDÆ.

Ostrea cuculata, BORN.—Back water, Manaar.

Ostrea (Lopha) crista-galli, LINN.—Deep water off Galle; Trincomalee.

Ostrea (Lopha) hyotis, LINN.—Trincomalee.

FAMILY: ANOMIIDÆ.

Anomia achæus, GRAY.—S. of Adam's Bridge.

Placuna placenta, LINN.—Tampalakam Lake, Trincomalee.

FAMILY: SPONDYLIDÆ.

Plicatula ceylanica, SOWERBY.—Gulf of Manaar.

Spondylus exilis, SOWERBY.—Gulf of Manaar; Trincomalee.

Spondylus flabellum, REEVE.—Trincomalee.

Spondylus imperialis, CHEMNITZ.—Deep water off Galle.

Spondylus layardi, REEVE.—Mutwal Island; Trincomalee.

FAMILY: LIMIDÆ.

Lima squamosa, LAMARCK.—S. of Cheval; Galle; Trincomalee; Muttuvaratu Paar.

Lima (Ctenoides) fragilis, GMELIN.—Gulf of Manaar.

Lima (Ctenoides) scabra, BORN.—Gulf of Manaar.

FAMILY: PECTINIDÆ.

Pecten flabelloides, REEVE.—Modragam Paar.

Pecten histrionicus, GMELIN.—Trincomalee.

Pecten irregularis, SOWERBY.—Galle.

Pecten layardi, REEVE.—Off Negombo, 20 fathoms.

Pecten miniaceus, REEVE.—Galle.

Pecten pallium, LINN.—Gulf of Manaar.

Pecten pseudolima, SOWERBY.—Modragam Paar.

Pecten pyxidatus, BORN.—Mudalaikuli Paar; Muttuvaratu Paar.

Pecten senatorius, GMELIN.—Trincomalee.

Pecten singaporinus, SOWERBY.—Trincomalee.

Pecten squamatus, GMELIN.—Galle.

Pecten (Pallium) pes-anatis, REEVE.—Galle; Modragam; Gulf of Manaar.

Pecten (Pallium) plica, LINN.—Trincomalee; Modragam; Gulf of Manaar.

Pecten (Pallium) velutinus, SOWERBY.—Off Mutwal Island.

FAMILY: AVICULIDÆ.

Avicula inquinata, REEVE.—Off Negombo, 20 fathoms.

Avicula iridescens, REEVE.—Off Negombo, 20 fathoms.

Avicula zebra, REEVE.—Gulf of Manaar.

Margaritifera vexillum, REEVE.—Palk Bay; Trincomalee; off Negombo.

Margaritifera vulgaris, SCHUMACHER.—Trincomalee; Gulf of Manaar, and many other localities (*vide* "Narrative").

Margaritifera margaritifera (LINN.).—Gulf of Manaar.

Malleus vulgaris, LAMARCK.—Off Mount Lavinia; W. of Pantura; Trincomalee; Gulf of Manaar.

Vulsella rugosa, LAMARCK.—Gulf of Manaar; Trincomalee.

Perna fimbriata, REEVE.—Gulf of Manaar.

Pinna attenuata, REEVE.—Gulf of Manaar.

Pinna bicolor, CHEMNITZ.—Trincomalee; Chilaw Paar; off Negombo; Gulf of Manaar.

Pinna chemnitzi, HANLEY.—Trincomalee.

Pinna fumata, HANLEY.—Gulf of Manaar; Trincomalee; Palk Bay.

Pinna zebuensis, REEVE.—Gulf of Manaar; Trincomalee.

Pinna (Atrina) nigra, CHEMNITZ.—Gulf of Manaar.

FAMILY: MYTILIDÆ.

Mytilus dunkeri, REEVE.—Trincomalee.

Mytilus smaragdinus, CHEMNITZ.—Tampalakam, Trincomalee.

Septifer bilocularis, LINN.—Jokkenpiddi Paar.

Septifer nicobaricus, CHEMNITZ.—Modragam Paar.

Modiolus barbatus, LINN.—Gulf of Manaar; Palk Bay.

Modiolus (Volsella) japonicus (DUNKER).—Gulf of Manaar; S. of Adam's Bridge, &c.

This mollusc forms a curious nest of gelatinous threads in which are entangled fragments of shell and grains of sand. These Ceylon specimens are less brightly marked, and the periostracum is darker than in specimens we have seen from Muscat.

Modiolus metcalfei, WOOD.—Trincomalee.

Modiolus tulipa, LAMARCK.—Aripu; Cheval Paar; Muttuvaratu Paar; Trincomalee.

Lithophagus caudigerus, LAMARCK.—Gulf of Manaar; Trincomalee.

Lithophagus gracilis, PHILIPPI.—Muttuvaratu Paar.

Lithophagus obesus, PHILIPPI.—Gulf of Manaar.

Crenella (Modiolaria) cœnobita, VIELLIOT.—Gulf of Manaar.

Crenella (Modiolaria) cumingiana, DUNKER.—Gulf of Manaar.

FAMILY: ARCIDÆ.

Arca navicularis, BRUG.—S. of Adam's Bridge; Aripu; Gulf of Manaar.

Arca noë, LINN.—S. of Adam's Bridge.

Arca zebra, REEVE.—Trincomalee; deep water off Galle.

Barbatia decussata, Sowerby.—Trincomalee; Muttuvaratu Paar; Gulf of Manaar.

Barbatia imbricata, Poli.—Gulf of Manaar; Muttuvaratu Paar.

Barbatia barbata, Linn.—S. of Adam's Bridge; Palk Bay.

Barbatia (Barbata) fusca, Brug.—Trincomalee; Welligam.

Barbatia (Barbata) lima, Reeve.—Galle; Trincomalee; Modragam; Navakaddu Paar; Gulf of Manaar.

Barbatia (Barbata) obliquata, Gray.—Trincomalee.

Anadara deshayesi, Hanley.—Gulf of Manaar.

Scapharca compacta, Reeve.—Palk Bay; Galle.

Scapharca pilula, Reeve.—Trincomalee.

Trisis (Parallelipipedum) tortum, Lamarck.—Palk Bay.

Cucullæa concamerata, Chemnitz.—S.E. of Ceylon; Gulf of Manaar.

Axinæa nodosa, Reeve.—Aripu; Gulf of Manaar.

Limopsis multistriata, Forskal.—S. of Adam's Bridge; Gulf of Manaar.

Family: CARDITIDÆ.

Cardita abyssicola, Hinds.—Muttuvaratu Paar; Modragam.

Cardita antiquata, Poli.—S. of Adam's Bridge; Trincomalee; Galle; Aripu; Gulf of Manaar.

Cardita radula, Reeve.—Mudalaikuli Paar; Gulf of Manaar.

Cardita variegata, Brug.—Trincomalee; Navakaddu.

Family: CRASSATELLIDÆ.

Crassatellites radiata, Sowerby.—Chilaw Paar; Trincomalee; Gulf of Manaar.

Crassatellites rostrata, Lamarck.—Gulf of Manaar; Aripu; Trincomalee.

Family: TRIDACNIDÆ.

Tridacna elongata, Lamarck.—Trincomalee.

Tridacna squamosa, Lamarck.—Trincomalee.

Family: CARDIIDÆ.

Cardium pulchrum, Reeve.—Deep water off Galle.

Cardium sueziense, Issel.—Off Negombo; Gulf of Manaar; Galle.

Cardium (Trachycardium) flavum, Linn.—Galle; Trincomalee; off Negombo.

Cardium (Trachycardium) lacunosum, Reeve.—Trincomalee; off Galle.

Cardium (Trachycardium) maculosum, Wood.—Aripu; Trincomalee.

Cardium (Trachycardium) oxygonum, Sowerby.—Trincomalee.

Cardium (Trachycardium) unicolor, Sowerby.—Trincomalee.

Cardium (Acanthocardia) asiaticum, Chemnitz.—Trincomalee.

Cardium (Cerastoderma) latum, Born.—Trincomalee.

Papyridea papyracea, Chemnitz.—Gulf of Manaar; S. of Adam's Bridge; Chilaw Paar; Galle.

Lævicardium attenuatum, Sowerby.—Trincomalee.

Lævicardium lyratum, Sowerby.—Gulf of Manaar.

Cardium (Serripes) muticum, Reeve.—Trincomalee.

Cardissa hemicardium, Linn.—Trincomalee.

Cardissa (Lunulicardia) subretusa (Linn).—Gulf of Manaar; Galle.

Family: CHAMIDÆ.

Chama foliacea, Quoy.—Trincomalee.

Chama macrophylla, Chemnitz.—Galle; S. of Cheval Paar; Gulf of Manaar.

Family: CYPRINIDÆ.

Isocardia lamarcki, Reeve.—Galle.

Family: VENERIDÆ.

Meretrix castanea, Lamarck.—Trincomalee; Tampalakam.

Meretrix sinensis, Chemnitz.—S.E. of Ceylon.

Lioconcha picta, Lamarck.—Off Negombo; Gulf of Manaar; Aripu; Trincomalee.

Circe scripta, Linn.—Aripu.

Crista pectinata, LINN.—Trincomalee.

Sunetta effossa, HANLEY.—Galle.

Sunetta meroë, LINN.—Trincomalee.

Dosinia ceylonica, DUNKER.—Galle.

Dosinia histrio, GMELIN.—Off Negombo; deep water off Galle.

Dosinia radiata, REEVE.—Gulf of Manaar; off Mutwal Island.

Chione (Omphaloclathrum) lamarcki, GRAY.—Gulf of Manaar; off Galle; off Negombo.

Chione (Omphaloclathrum) layardi, REEVE.—Galle.

Chione (Omphaloclathrum) reticulata, LINN.—Trincomalee.

Callista phasianella (DESHAYES).—Gulf of Manaar.

Anaitis foliacea, PHILIPPI.—Off Negombo; Modragam.

Tapes textrix, CHEMNITZ.—Palk Bay; S. of Adam's Bridge.

Tapes (Amygdala) bruguierei, HANLEY.—Welligam; Trincomalee.

FAMILY: PETRICOLIDÆ.

Petricola cultellus, DESHAYES.—Modragam.

FAMILY: CYRENIDÆ.

Cyrena tennentii, HANLEY.—Trincomalee.

FAMILY: UNGULINIDÆ.

Diplodonta bullata, DUNKER.—Trincomalee.

Diplodonta indica, DESHAYES.—Galle.

FAMILY: DONACIDÆ.

Donax (Hecuba) scortum, LINN.—Welligam Bay.

Donax (Latona) cuneatus, LINN.—Trincomalee.

FAMILY: GARIIDÆ.

Gari amethystina, REEVE (**Psammobia**, LAMARCK).—Trincomalee.

Gari præstans, DESHAYES.—Aripu.

Gari squamosa, LAMARCK.—Galle.

Hiatula diphos, LINN. (**Soletellina**, BLAINVILLE).—Tampalakam.

Hiatula (Psammotæa) radiata, DESHAYES.—Trincomalee.

Asaphis deflorata, LINN.—Trincomalee.

FAMILY: MACTRIDÆ.

Mactra antiquata, SPENGLER.—Gulf of Manaar.

Mactra luzonica, DESHAYES.—Gulf of Manaar; Galle.

Mactra ornata, GRAY.—Off Negombo; Aripu; E. of Ceylon.

Hemimactra (Oxyperas) triangularis, LAMK.—Off Negombo; G. of Manaar; Galle.

FAMILY: GASTROCHÆNIDÆ.

Gastrochæna clava, LAMARCK (**Fistulana**, BRUGUIÈRE).—Palk Bay.

Rocellaria lagenula, LAMARCK (**Gastrochæna**, LAMARCK).—Modragam.

FAMILY: PHOLADIDÆ.

Martesia striata, LINN.—Between Negombo and Chilaw.

FAMILY: MYIDÆ.

Corbula crassa, HINDS.—Muttuvaratu Paar.

Corbula modesta, HINDS.—Modragam; Gulf of Manaar.

Corbula scaphoides, HINDS.—Navakaddu Paar.

FAMILY: TELLINIDÆ.

Tellina (Tellinella) rostrata, LINN.—S.E. of Ceylon.

Tellina (Tellinella) virgata, LINN.—Gulf of Manaar.

Tellina (Peronæa) cygnus, HANLEY.—Gulf of Manaar.

FAMILY: CUSPIDARIIDÆ.

Cuspidaria chinensis, GRAY.—Trincomalee.

FAMILY: SCROBICULARIIDÆ.

Semele crenulatum, SOWERBY.—Modragam.

FAMILY: ANATINIDÆ.

Anatina labiata, REEVE.—Five miles N. of Cheval Paar.

REPORT

ON THE

TUNICATA

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

W. A. HERDMAN, D.Sc., F.R.S.,
PROFESSOR OF ZOOLOGY IN THE UNIVERSITY OF LIVERPOOL.

[WITH NINE PLATES.]

THIS collection of Tunicata is not a large one and yet it is by far the largest that has, so far as is known, ever been brought from the Ceylon seas, and it more than trebles the number of species recorded from the northern part of the Indian Ocean. Most of the Tunicata known to science have been described from specimens found on the coasts of Europe and of North America, in Malaysian seas, in the Antarctic or on the Australian shores; and it is curious how few have been found in tropical seas outside the West Indies and the Malay Archipelago.

In 1891, in the 'Revised Classification of the Tunicata,' I was able to record only 13 species as known from the Indian Ocean, and of these three were Salpidæ—the species of Ascidiacea being only *Molgula martensii*, TRAUSTEDT, *Microcosmus claudicans* (SAVIGNY), *Rhabdocynthia mauritiana* (v. DRASCHE), *Rh. pallida* (HELLER), *Polycarpa nigricans*, HELLER, *Styela areolata*, HELLER, *Corella novaræ*, v. DRASCHE, *Ascidia depressiuscula*, HELLER, *Ecteinascidia thurstoni*, HERDMAN, and *Polyclinum constellatum*, SAVIGNY.

If, however, the "Indian Ocean Area" in a wide sense be extended so as to embrace the Red Sea, the seas of Malaysia and the coasts of Australia, a very large number of additional species will be brought in. On the other hand, the 1891 list contains only three species recorded actually from the coast of Ceylon, viz., *Ascidia*

depressiuscula, HELLER, and *Styela areolata*, HELLER, both collected by Professor SCHMARDA, and *Ecteinascidia thurstoni*, which I described, in 1890, from a colony obtained by Mr. EDGAR THURSTON on the pearl banks in the Gulf of Manaar. Another species of *Ecteinascidia* described below, although from the same locality, seems to be quite a distinct form.

Since 1891, SLUITER has described 28 new species of Ascidians from the shores of South Africa (mostly Capetown, Durban and Mozambique), but these, although in the Indian Ocean, are still between two and three thousand miles distant from Ceylon. SLUITER has also described a large number of new species from Malaysian seas, as the result of the "Siboga" expedition. A few of these occur in the present collection, but the majority of the Ascidians of the Malay Archipelago seem to be distinct from those of the coast of Ceylon, although closely allied forms. It is interesting to have re-found the two species originally brought from Ceylon by SCHMARDA, and also to have obtained the recently described, curious, compound Ascidian *Hypurgon*, I. B. SOLLAS, which forms a skeleton with its own hardened fæcal pellets.

SLUITER and I seem to have expressed somewhat divergent views, in our recent works, on the geographical distribution of Tunicata, but the differences may possibly be more apparent than real. They are due to the vibrations of the scales, as first one and then the other of us brought to be weighed fresh batches of new species from different parts of the world. Successive advances in knowledge led to changes in opinion. As the result of my examination of the "Challenger" material, I came to the conclusion, quite justified by the facts then known, that the fixed Tunicata were more abundant and larger in southern than in northern or tropical seas. A few years later SLUITER, as the result of his explorations round the island of Billiton (Dutch East Indies) described a large number of tropical new species of Ascidians, and so was led to correct my opinion—which he did vigorously. After another interval of years, the large collections belonging to the Sydney Museum passed through my hands, and this enabled me to describe such a considerable number of additional southern species as to cause me, after careful weighing of the evidence, including, of course, SLUITER'S tropical forms, to come to the conclusion that the balance was again in favour of the far south. Since then several notable additions have been made to our knowledge of the Indo-Malayan fauna; and the rapidity with which the number of known species is being added to by each successive expedition indicates that our knowledge of the distribution of the group is still far from complete. But whatever result the actual number of species from the tropics and from the polar regions may give us in the future, I believe that the Ascidian fauna of the far south is characterised by the abundance of individuals and by their large size.

Believing that in the present state of our knowledge of the species of Tunicata careful drawings are quite as important as descriptions, and realising from my own experience how valuable some detail of an illustration may be in the identification of a species, I have endeavoured, in the present case, to illustrate fully the appearance

and structure of the new species, and even in some cases to give additional figures of species that are known to science.

In regard to the classification, I have arranged the species under their Families, and have not made use of any higher groupings. There is still some difference of opinion amongst authorities as to the correct position and divisions of that polyphyletic group, the compound Ascidians, and until these matters are settled there can be no practical inconvenience in omitting, in a report of this nature, the names of larger groups and in making use merely of the "Family" designations.

Sluiter, in 1900, remarked upon the scarcity of Ascidiidæ in the Pacific Ocean, and stated that the "Schauinsland" collection of 36 species contained no representative of that family. Since then, however, he has described a large number of new species of *Ascidia* from Malaysian seas in his '"Siboga" Report.' I was also struck, when in Ceylon, by the paucity of Ascidiidæ, especially when compared with northern and southern seas, where, in places, they constitute the characteristic feature of the Ascidian fauna. Another family most feebly represented in the tropics is the Botryllidæ, which contains, perhaps, the most abundant of colonial forms in northern temperate seas. The most notable character of the Ceylon Ascidian fauna is the wide distribution and abundance of the genus *Leptoclinum*, and, in fact, of calcareous and sandy forms in general. Species of *Leptoclinum*, and to a less degree of *Psammaplidium*, are found nearly everywhere around Ceylon, and are the largest and most conspicuous, as well as the most abundant of compound Ascidians. Species of *Rhabdocynthia* with calcareous spicules are also abundant, and some of them have a sandy covering. Sandy simple Ascidians are very numerous, and belong to at least three distinct families. Although most of them at first sight might be supposed to be Molgulidæ, the majority are Cynthiidæ, and some are Ascidiidæ. Sandy balls of very similar appearance have proved to belong to the genera *Ascidia*, *Styela*, *Polycarpa*, *Rhabdocynthia*, *Microcosmus*, *Molgula* and *Ctenicella*. As is usual in warmer seas, the majority of the simple Ascidians are species of *Polycarpa* and *Styela*, but *Rhabdocynthia*, *Ecteinascidia* and the Polystyelidæ may also be mentioned as characteristic forms.

Sluiter, in his '"Siboga" Report,' estimates that there are about 200 species of Tunicata in the Malaysian seas, and nearly the same number (183 recorded in 1899) are known from the coasts of Australia. Compared with these figures, the 64 species described below seem to represent rather a poor fauna, but even if this be the case in regard to species, it is certainly not true of individuals. Both on the coral reefs of Galle and Aripu, and also on some of the paars in the Gulf of Manaar, compound Ascidians are abundant, and in some places fine specimens of *Leptoclinum* bulk large in the dredge and the collecting jars.

About three-fourths of the species found seem to be new to science, but that is to be expected on a coast where the Ascidian fauna has not before been specially investigated.

As an example of the number of Tunicata that live along with, and may be said to infest, the pearl oyster, I give the following list of species found on examining the oyster-cages suspended from the ship when on the Cheval Paar: *Ascidia donnani*, *Rhabdocynthia ceylonica*, *Diandrocarpa brakenhielmi* var. *ceylonica* (many colonies), *Botryllus ater*, *Botrylloides chevalense* (many colonies), *Diplosoma gelatinosum*, and several smaller colonies of *Leptoclinum*, and other compound Ascidians undetermined. In addition, many other species were found attached to and encrusting the pearl-oysters on the bottom. Notable cases are *Styela areolata*, *Rhabdocynthia pallida*, *Psammaplidium ceylonicum*, and *Leptoclinum margaritiferæ*.

Even colonies attached to other objects on the bottom, such as the Leptoclinids growing over the sand, must have their influence in competing for microscopic food, and thus the fixed Tunicata may fairly be classed amongst the enemies of the pearl oyster in the passive struggle for existence.

DESCRIPTION OF THE TUNICATA.

Family: CLAVELINIDÆ.

Perophora hornelli, n. sp.—Plate I., figs. 1 to 8.

External Appearance.—Small colonies of a few Ascidiozooids and buds each (fig. 1), attached to a slight stolon which is encrusted with sand (fig. 3). The atrial aperture has five or six lobes (fig. 6). Colour, dull greenish brown (in spirit). Size, 4 millims. in length by 2 to 2·5 millims. in breadth.

Test very thin.

Mantle with numerous fine interlacing muscle bands, mostly transverse in direction.

Branchial Sac with rather short wide stigmata (figs. 4, 5). Some parts of the sac are papillated and others not. The papillæ split at their ends and send prolongations anteriorly and posteriorly to form incipient bars (fig. 5). In some parts of the sac the bars are complete and bear small papillæ (fig. 4).

Dorsal Languets short and triangular in shape (fig. 8).

Tentacles in three series (fig. 8). There are about 10 of each of the two larger series. Those of the third, most anterior, series are very much smaller.

Dorsal Tubercle with a simple circular aperture (fig. 8).

Alimentary Canal showing a simple stomach and several differentiated regions in the short wide intestine (fig. 7).

Locality:—On Navakaddu Paar, in the southern part of the Gulf of Manaar; depth, 8 fathoms.

This species agrees with Verrill's *Perophora viridis*, from the East Coast of North America, which is possibly the same as Lahille's *P. banyulensis* from the Mediterranean, in having the more or less complete system of internal bars in the branchial sac shown in the figures (Plate I., figs. 4 and 5).

The tentacles, however, are more numerous than in *P. viridis*, and are arranged distinctly in three rows (fig. 8). The zooids are of unusually large size, and the stolon is encrusted with sand. The atrial aperture is distinctly five-lobed. This species thus presents a combination of characters seen separately in several other species, and does not agree entirely with any. I have pleasure in associating this new species with the name of my colleague in the pearl fisheries investigation, Mr. JAMES HORNELL, F.L.S., who was with me on the barque "Rangasami-Poravi" on April 2, 1902, when the specimens were collected.

Ecteinascidia thurstoni, HERDMAN.—Plate I., figs. 18 to 23.

This species was originally found in the Gulf of Manaar by Mr. EDGAR THURSTON, and was described by me in 1890* and named in honour of its discoverer. The type specimen is in the Government Central Museum, Madras. The species has since been recorded from Bermuda by VAN NAME, and from the Bay of Djibouti, Somali-land, by GRAVIER.

The colonies which I now refer to this species were collected on Aripu coral reef on March 18, 1902, and are attached to fragments of a massive sponge. One colony (fig. 18) has about 14 Ascidiozooids, another has two or three only, the third has half a dozen large and small with a few buds in addition; and there are also a few loose Ascidiozooids (fig. 19) detached from colonies.

All the Ascidiozooids, although transparent, are of a slightly pink colour, like the sponge they grow over; but it is possible this may be a *post-mortem* effect produced by staining with the pigment dissolved out from the sponge. The largest Ascidiozooid measures 8 millims. × 3 millims.—a more usual size is 5 millims. in length. In THURSTON's specimens the Ascidiozooids were rather larger, and ranged from 7 millims. to 2 centims. in length. Otherwise the appearance of the colonies is very similar, and the internal structure is also very much the same in the two cases. In our specimens the branchial aperture may be seven-lobed and the atrial six-lobed (fig. 23). The meshes of the branchial sac generally contain three stigmata; four is the number given in the description of *E. thurstoni*. The rest of the branchial sac and the dorsal languets (fig. 21) seem to agree well; but the tentacles are not so numerous and closely placed in our present form (fig. 20), where there seem to be about 60 in all, of three sizes. Possibly the rather smaller size, fewer stigmata and less closely placed tentacles may all be co-related characters indicating merely a younger stage in growth. The course of the alimentary canal and gonads (fig. 22) seem alike in the two cases.

Ecteinascidia (? Rhopalopsis) solida, n. sp.—Plate I., figs. 15 to 17.

External Appearance.—Shape, a cylindrical finger-like mass somewhat bent at the free end, attached posteriorly by a broad base and with both apertures at the anterior end. Surface smooth; size about 2·5 centims. × 1 centim.

* 'Trans. Biol. Soc., Liverpool,' vol. v., p. 144.

Test thick and stiff, forming a more solid mass than is usual.

Mantle delicate, with about ten slight longitudinal muscle-bands on each side.

Branchial Sac with internal bars supported by wide triangular connecting ducts (fig. 16). Meshes each contain two or three rather wide stigmata.

Dorsal Lamina represented by a series of closely placed rather large triangular languets (fig. 17).

Tentacles rather long, eight larger and eight smaller.

Dorsal Tubercle very small and simple.

Locality:—Coral Reef, Galle, February 14, 1902; one specimen.

Ecteinascidia sluiteri, n. sp.—Plate I., figs. 9 to 14.

External Appearance.—A small transparent colony consisting of two individuals and an empty test, and some buds attached to a slender creeping stolon (fig. 9). The stolon is marked with constrictions or joints, and has some adhering sand (fig. 10). The Ascidiozooid is oblong and erect, with both siphons at the anterior end, and rapidly narrowing at the posterior end to the attachment with the stolon. The apertures are not lobed, but have many slight creases. The Ascidiozooid measures 7 millims. in length by 3·5 millims. in breadth at the atrial siphon. The stolon is about 4 centims. in length.

Test thin and colourless, allowing the branchial sac to be seen through.

Mantle thin, and for the most part transparent. The muscles are arranged in three longitudinal bands (one dorsal and two lateral) of short, transversely running forked bundles. The dorsal band is interrupted in its posterior three-fourths by the rectum (fig. 11).

Branchial Sac large, and runs the whole length of the body. The transverse vessels are narrow and all alike; the internal bars are very narrow and the connecting ducts are slight. The stigmata are long and regular, one or two to a mesh (fig. 12).

Tentacles of two sizes, and there are about twenty in all. Those at the ventral edge are the largest (fig. 13). A large number of Acinetan parasites are seen attached to the tentacles and to the peripharyngeal band.

Dorsal Lamina represented by a series of very small languets. There is very little interruption of the stigmatic network on the dorsal edge.

Dorsal Tubercle a small simple rounded opening (fig. 13).

Alimentary Canal slender. The stomach has slight longitudinal folds and narrows at the pyloric end, where the intestine is constricted (fig. 14).

Locality:—Station LVIII., off north end of Karativo Island, 9 to 26 fathoms.

The chief peculiarities of this species are the constricted stolon and the peculiar short forked muscle bundles suggesting the condition seen in some species of *Corella* (*e.g.*, *C. japonica*), and the well-marked siphons which caused us to enter the animal when dredged as an "Ascidia-like Clavelinid" in our field-notes.

Omitting from consideration those species described as "Ecteinascidia," which have

since been separated off into the allied genera *Rhopalæa*, *Rhopalopsis*, and *Sluiteria*, there remain seven closely allied species amongst which the present one must take its place; they are:—*Ecteinascidia turbinata*, HERDMAN, from Bermuda; *E. diaphanis*, SLUITER, from Malaysia; *E. moorei*, HERDMAN, from Alexandria; *E. thurstoni*, HERDMAN, from the Gulf of Manaar; *E. garstangi*, SLUITER, from Mozambique; *E. euphues*, SLUITER, and *E. psammodes*, SLUITER, both from the Australian Coast. From all these the present species appears to differ either in external characteristics or in internal structure. The two last-named species were described by SLUITER from SEMON'S collections, and are very minute forms (the Ascidiozooids being only 2 to 3 millims. long) which show some resemblance, as their author has pointed out, to the genus *Perophora*, and especially to such a species as *P. hutchinsoni*, MACDONALD. The two remaining species of *Ecteinascidia*, *E. nexa*, SLUITER, and *E. multiclathrata*, SLUITER, from the "Siboga" expedition, are both somewhat exceptional forms showing an approach in some of their characters to the genus *Sluiteria*, although differing from that genus in other essential points. From these, and from all other described species of *Ecteinascidia*,* the present species differs notably in having distinct and prominent siphons (Plate I., fig. 9) which give to the anterior end of the body very much the appearance of a *Ciona*. Another noteworthy feature is the arrangement of the muscles in the mantle (fig. 11) which is quite unlike that in any other known species of this genus.

Ecteinascidia seems to be a tropical type of Ascidian structure, occurring, so far as we know at present, only between Bermuda to the north and the north coast of Australia to the south, and having its main development in eastern seas. Out of ten known species, eight occur in the Indian Ocean and Malaysian seas, viz., *E. garstangi* (Mozambique), *E. psammodes* (Australia), *E. diaphanis* (Malay), *E. euphues* (Malay), *E. nexa* (Malay), *E. multiclathrata* (Malay), *E. thurstoni* (Gulf of Manaar), and the present new species, *E. sluiteri*, from the coast of Ceylon.

I have much pleasure in naming this species in honour of Professor SLUITER, of Amsterdam—the author who has described most of the species of this genus.

FAMILY: ASCIDIIDÆ.

Rhodosoma ceylonicum, n. sp.—Plate I., figs. 24 to 33.

External Appearance.—Body, when retracted, of short cylindrical, ovate, or deep cup-shaped form, with a rounded posterior and a flattened anterior end forming the operculum over the apertures. Attached by the anterior part of the right side just below the test that forms the hinge of the operculum. The siphons are close together and are directed forwards, a slight fold rises behind each siphon (fig. 27). Surface covered with small sharp papillæ on the anterior half, especially round the

* Such as *E. diligens*, SLUITER, from the Pacific, which seems an exceptional form.

edges of the opening, smooth on the posterior half of the body. Colour a translucent pinkish grey, or sometimes grey-green, rather redder on the anterior end and especially on the siphons which are bordered with yellowish green. Size, 1·7 centims. × 1·2 centims. × 1 centim.

Test of a soft cartilaginous consistency, semi-transparent, echinated around the anterior end, smooth posteriorly, with an occasional little tubercle; a few small shell fragments adhering to test near area of attachment.

Mantle with five pyriform muscle masses on each side; the one set run towards the atrial siphon (fig. 28) and the other set towards the branchial. In addition to these there are finer bundles and the siphons are strongly muscular (fig. 29), having both longitudinal and transverse bands of considerable bulk.

Branchial Sac with wide, regular, rounded stigmata arranged two (rarely three) in a mesh (fig. 30). The transverse vessels are all of one size. The internal bars are narrow and have short papillæ. Along the dorsal edge of the sac the internal bars are imperfect, the branches arising from the transverse vessels forming triradiate processes (fig. 31) which do not meet across the mesh to form a bar.

Dorsal Lamina a series of long narrow pointed languets (fig. 32).

Tentacles of three sizes, closely placed; about sixteen of each of the two larger sizes and about double that number of very much smaller ones.

Dorsal Tubercle deeply crescentic, the horns pointing towards one another across the opening (fig. 33).

Localities:—(1) Palk Bay, March 16, trawling, one specimen 1·7 centims. long, and one 8 millims. long; (2) Gulf of Manaar, adhering to a fragment of a large chank shell, 10 fathoms, 2 specimens, also on coral fragments; (3) off Mount Lavinia, Station XLVI., 30 fathoms, one specimen in a crevice on coral mass, "pale grey-green, apertures bordered with yellowish green."

It is not easy to say whether the specimens of *Rhodosoma* from Ceylon can be safely identified with any of the species already named (we can scarcely say "known"). In 1855 STIMPSON very briefly described two species, *Schizascus pellucidus* and *S. papillosus*, both from China, which seem to differ so little, if we may judge from the published descriptions, that they may well be one species—belonging to the genus *Rhodosoma* of EHRENBERG (1828); but not to EHRENBERG's species *R. verecundum*. In 1878 HELLER described, almost equally briefly, *Rhodosoma seminudum* from Jamaica, and gave a figure of the exterior which, however, shows no very distinctive features; so much so that TRAUSTEDT, in 1882, describing specimens of the genus from the same neighbourhood (West Indies), hesitated to refer them to HELLER's species, and gave them the name *Rhodosoma pyxis*, followed by a detailed description. He distinguished this species clearly from *R. callense* (LAC. DUTH.), the only other sufficiently described form. SLUITER, however, in 1898, took a different view and refused to share TRAUSTEDT's doubts. He appropriates TRAUSTEDT's accurate anatomical description to HELLER's diagnosis of *R. seminudum*,

and is satisfied that his own specimens (from the "Chazalie" expedition) belong to that species. The Australian forms *Pera* and *Peroides* of MACDONALD probably also belong to this genus. HARTMEYER, in 1901, re-described with anatomical details EHRENBERG'S *Rhodosoma verecundum* and STIMPSON'S *Rh. papillosum;* and SLUITER, in 1904, in reporting on the Tunicata of the "Siboga" expedition, accepts HARTMEYER'S adequate description as applying to STIMPSON'S brief diagnosis, and refers all his specimens (about a dozen) from nine localities in eastern seas to the species *Rh. papillosum*, STIMPS. He notes, however, a certain amount of difference between some of his specimens and HARTMEYER'S description. I find also certain points of difference in detail between the Ceylon specimens and the descriptions of HARTMEYER and SLUITER, and, so far as external appearance goes, my specimens when alive agreed rather better with STIMPSON'S three lines on *Schizascus pellucidus* than with his two lines on *S. papillosus.* Consequently one course open to me, if I consider my specimens distinct from *Rh. papillosum*, as re-described by HARTMEYER, would be to refer them to STIMPSON'S *Rh. pellucidum* and so place my new description under his specific name. But although there is nothing prohibitive of this in STIMPSON'S words, neither is there anything very characteristic that leads us to identify the species without doubt. Consequently, I believe it will be least confusing for future workers, and most conducive to scientific clearness, if the Ceylon specimens are described as a distinct species under a new name, as above. The characters are sufficiently given in the description and shown in the figures on Plate I. The branchial sac (fig. 30) will be seen to differ from both that of *Rh. papillosum* and that of *Rh. verecundum*, as figured by HARTMEYER ('Arch. f. Naturges.,' 1901, Beiheft, Taf. iv.).

Ascidia donnani, n. sp.—Plate II., figs. 1 to 9.

External Appearance.—Shape irregularly ovate, posterior end rounded, anterior narrower and truncated. Attached by the posterior half of the left side. Branchial aperture on dorsal part of anterior end, atrial aperture on dorsal edge of body, one-third back; both apertures somewhat prominent, lobed. Test drawn out into several jagged processes, especially on dorsal and ventral edges (fig. 1). Surface roughened with small asperities. Colour grey (in spirit). Size, 2·4 centims. × 1·5 centims.

Test thin, cartilaginous; thickened in places to form the irregular processes shown in the figure. It contains the usual vessels and bladder-cells.

Mantle with moderately developed musculature and prominent siphons. The atrial siphon is directed backwards, so as to give the body when removed from the test (fig. 2) a somewhat triangular shape. Under the microscope the muscle bands are seen to narrow very abruptly (fig. 7) and end in fine bundles of connective-tissue fibres spirally coiled.

Branchial Sac with rather large square meshes containing each about half a dozen long narrow stigmata (fig. 5). The transverse vessels are mostly narrow and nearly

all of much the same size, but every fourth one is in places wider than the three intermediates and has a rather wider horizontal membrane. The papillæ on the rather narrow internal bars are large. They vary in length, but on the average extend about half-way across the mesh.

Dorsal Lamina a wide membrane with well-marked shelf-like ribs, and marginal points (fig. 6). The ribs die away as they approach the free edge.

Tentacles numerous and rather slender, 50 to 60, larger and smaller, but none very small (fig. 9).

Dorsal Tubercle large, cordate in outline, with the posterior end pointed, the opening anterior and both horns rolled inwards (fig. 4).

The Viscera occupy the ventral half of the rather wide posterior end of the body (fig. 3). The intestine is relatively wide.

Locality :—(1) Navakaddu Paar, Gulf of Manaar, 8 fathoms, 1 specimen ; (2) outer Chilaw Paar, Station LXIX., depth 8 to 11 fathoms, 2 specimens ; (3) Cheval Paar, attached to oyster cages, 2 specimens.

This species is described above from the single large specimen obtained on Navakaddu Paar ; but the couple of Ascidians from Cheval Paar and those from Chilaw Paar are probably also specimens of the same species. They have not all the same external appearance, but the internal organisation appears to correspond fairly well. One of the larger specimens is partly overgrown by a colony of *Botrylloides*, and that may account for some difference in shape and appearance, while a couple of smaller specimens (1 centim. long) are probably young and still undeveloped. The body of the larger specimen from Chilaw Paar when removed from the test is shown in fig. 8. The siphons are especially long and are ridged longitudinally and provided with slight tag-like processes of connective tissue. The muscle bundles are especially prominent round the edges of the right side of the mantle. Fig. 9 shows the dorsal tubercle and tentacles of this specimen from Chilaw Paar. In the shape of the body and especially in the long siphons, and also in the distribution of the muscle bundles round the edges of the right side (fig. 8), this specimen recalls the "*Ascidia canaliculata* (HELLER)?," described by SLUITER, in 1885, from Billiton, which he later (1898) decided to recognise as a distinct species under the name of *Ascidia divisa*—but differs markedly from that form in the structure of the dorsal tubercle. Nor does it agree with the true *A. canaliculata*, HELLER, as described by SLUITER and others ; nor yet with *A. bisulca*, SLUITER, which it resembles superficially, but differs from in the details of the branchial sac and dorsal lamina. The species to which it is most nearly related is *Ascidia longitubis* (TRAUSTEDT) from the West Indies. The agreement extends to the body form, the musculature, and the dorsal tubercle ; but the two species differ in the details of the branchial sac. It is possible, however, that several of these species which have been mentioned above may come to be united when a larger range of specimens and of variations have been studied.

This new species is named in honour of Captain DONNAN, C.M.G., for many years

Inspector of the Pearl Banks, Ceylon, and who was with me in the Gulf of Manaar performing his last inspection in the spring of 1902 when these specimens were collected.

Ascidia depressiuscula, HELLER—Plate II., figs. 10 to 22.

Although I refer these specimens to HELLER'S species, I consider it desirable to give a detailed account of them with figures, as HELLER'S description was brief and had no illustrations of the internal structure.

External Appearance.—Body flattened, ovate in outline, attached by the whole of the left side and posterior end. Apertures both on right side, on the anterior half of the dorsal edge, small, not projecting. Right side of body rather depressed in centre with more prominent rounded edges. Surface smooth; colour (in spirit), grey, with a slight brownish tinge. Size, 2 centims. × 1 centim. to 1·5 centims. × 3 millims. to 5 millims. in thickness.

Test cartilaginous, but rather thin, semi-transparent.

Mantle with moderate siphons. The visceral mass on the left side is rather large.

Branchial Sac having the meshes square or a little elongated transversely. All the transverse vessels are very narrow, so that the ends of the adjacent rows of stigmata are very close. Every eighth transverse vessel has, however, a wider horizontal membrane than the intermediate seven. The stigmata are of moderate size and about five or six to a mesh. The internal longitudinal bars are stout with large knob-like papillæ and occasionally smaller ones between (fig. 17); there are also intermediate horizontal membranes crossing the meshes in places.

Dorsal Lamina a plain membrane with slight, but distinct, transverse ribs and small marginal denticulations (fig. 18).

Tentacles numerous, about 60 to 80, much the same size, with an occasional very much smaller one (fig. 21).

Dorsal Tubercle large, horse-shoe-shaped (figs. 19 and 20), with the opening anterior and both horns coiled inwards. The nerve ganglion is placed close up under the dorsal tubercle. The prebranchial zone is papillated.

Alimentary Canal rather bulky, intestine wide, and full of fine mud (fig. 22).

Gonads well developed. Vas deferens swollen.

Localities:—(1) Galle Bay, from a basket of pearl oysters attached to a buoy, seven specimens; (2) Station LIV., north of Gulf of Manaar, depth 4 to 40 fathoms; one specimen along with many Cynthiidæ.

The specimens from Galle are all very much alike in their characters, and figs. 10, 11 and 12 give the appearance and range in size. Fig. 14 shows the specimen from the Gulf of Manaar, measuring 2 centims. × 1·5 centims. × 5 millims.

The branchial sac of the Manaar specimen (fig. 15) differs a little from that of the Galle specimens. It has the papillæ relatively longer, the stigmata rather shorter, and the meshes squarer. But as pieces of the branchial sacs from Galle differ a little

in such characters amongst themselves (figs. 16, 17), the matter is probably of no systematic importance and the whole series may be regarded as one species.

One point of interest belonging to these specimens from Galle is that, from the circumstance of their attachment to the basket which was put out on April 17 and brought in on May 9, it is known that they grew to a length of 2 centims. and became sexually mature within a period of three weeks.

This is one of those troublesome species that show no very striking characteristics and yet do not agree exactly with any other species. In external appearance the specimens agree in general with several common species of *Ascidia*, such as *A. prunum*, O. F. M., *A. obliqua*, Ald., *A. scabra*, O. F. M., and *A. mollis*, Ald. and Hanc., but they differ from all these northern species in some details of organisation. With some hesitation I have decided to identify them with Heller's *Ascidia depressiuscula* obtained in Ceylon by Schmarda. The external appearance agrees fairly well with Heller's figure ('Sitzb. Akad. Wiss. Wien.,' Jahrg. 1878), and the internal structure does not differ from Heller's brief description except in regard to the number of tentacles.

The very small number of species of the large and usually abundant genus *Ascidia* found in the Ceylon collection is remarkable, especially when we remember that Sluiter describes no less than 24 species ot *Ascidia* (11 of them new to science) in the results of the "Siboga" expedition through the Indian Archipelago further east.

Ascidia (?) mikrenterica, Sluiter—Plate I., figs. 38 and 39.

There is a single specimen of an *Ascidia* with a thick sandy covering, obtained at Station LXII., 13 fathoms, which I refer with some doubt to this species. It has been torn open, probably by the dredge when captured, and the anterior end is absent. In the thick coating of sand, and in the relatively minute alimentary canal (fig. 38), it resembles the "Siboga" species, but the structure of the branchial sac (fig. 39) is different. However, I have seen so many abnormal branchial sacs, or portions of branchial sacs, amongst known species that I cannot attach much importance to the reduced size and number of the stigmata seen in this specimen.

Ascidia polytrema, n. sp.—Plate I., figs. 34 to 37.

External Appearance.—Oblong-ovate, with the posterior end rounded, the branchial aperture on the anterior end and the atrial projecting from the dorsal edge about one-third of the way back (fig. 34). Surface sandy; size, 3·3 centims. × 1·6 centims.

Test thin, with large grains of sand and shell fragments embedded in it.

Mantle thin and weak; delicate muscle bundles running transversely (fig. 36).

Branchial Sac exceedingly thin and delicate. Internal longitudinal bars bearing slight papillæ. Meshes about square, with four stigmata in each. Occasional horizontal membranes cross the meshes (fig. 37).

Dorsal Lamina with slight ribs and minute marginal denticulations.

Dorsal Tubercle with one minute opening at the apex of a deep triangular peri-tubercular area and about 20 supplementary ciliated funnels further back, but in front of the ganglion, and opening into the peribranchial cavity (see fig. 35). Pre-branchial zone with slight papillæ scattered over it.

Alimentary Canal rather large, with very weak walls, and having the wide intestine distended with mud containing many diatoms.

Locality:—South ends of Cheval and Periya paars, Station XLIX., 8 to 12 fathoms; one perfect specimen and a broken fragment of another, much larger, with no viscera.

Family: MOLGULIDÆ.

Molgula taprobane, n. sp.—Plate IV., figs. 14 to 19.

External Appearance.—Erect, rounded oblong, unattached, with the two short siphons near together on the anterior end, not diverging. Covered with fine sand (fig. 14); size, about 1 centim. across.

Test thin and soft, with a thin coating of sand.

Mantle thin and transparent (figs. 15 and 16).

Branchial Sac with seven folds on each side. Each fold shows three bars. The stigmata are for the most part straight or very slightly curved between the folds, but on each side of the dorsal lamina (fig. 17) they are well coiled.

Tentacles, 12 of one size, moderately branched, not bushy, with much smaller intermediate ones, and very minute simple tags between these.

Dorsal Lamina a plain narrow membrane (fig. 17).

Dorsal Tubercle obliquely cordate, with the aperture directed laterally and backwards (fig. 19).

Gonads present on both sides.

Localities:—(1) Station LIII., 10 miles north of Cheval Paar, 9 fathoms; (2) Station XXII., Trincomalee, 13 fathoms; (3) Station XLVI., off Mount Lavinia, 30 fathoms. Fig. 18 shows the specimen from Trincomalee.

The specific name of this first *Molgula* recorded from Ceylon is the ancient classical name of the island.

Ctenicella ridgewayi, n. sp.—Plate IV., figs. 20 to 23.

External Appearance.—Body globular, free, covered with sand. Both siphons at anterior end divergent (fig. 20). Size, 1·3 × 1 centim.

Test thin, covered with adhering sand.

Mantle with muscular siphons, and having the marginal lobes pinnate (fig. 22).

Branchial Sac with seven folds on each side. There are four bars on each side of the fold and the anterior extremities of the folds are papillose. The meshes are large and each contains many well-coiled stigmata (fig. 23).

Tentacles much branched, and at least 12 in number.

Dorsal Lamina a plain membrane.

Dorsal Tubercle a simple horse-shoe, with the opening on one side (fig. 21).

Locality :—Station LIII., 10 miles north of Cheval Paar, 9 fathoms.

This little Molgulid is externally very similar to the Polycarpa (*P. decipiens*), the *Styela* (*S. lapidosa*), and the *Rhabdocynthia* (*Rh. ceylonica*), with which it is found.

I have named this species after Sir West Ridgeway, who was Governor of Ceylon at the time when it was collected.

Family: CYNTHIIDÆ.

Notwithstanding Michaelsen's remarks ('Zool. Jahrb.,' Suppl. viii., 1905, p. 79), and the fact that several recent writers have seen fit to relinquish the genus *Rhabdocynthia*, I believe it is both useful and natural to group together those species of "Cynthia" that show echinated unbranched calcareous rods or spindles in the connective tissue of the body. The grouping of species into genera is largely a matter of convenience, and if a set of closely related species can be defined and recognised by the possession of a common character, the application of a generic name seems justifiable, and is certainly an aid in classification. On these grounds I make use of *Rhabdocynthia* as the generic designation of the set of species which may be grouped around Heller's *Cynthia pallida*.

Rhabdocynthia pallida (Heller)—Plate II., figs. 36 to 39.

The shape is irregularly ovate or pyriform, the anterior end being rather the wider. It is attached by the posterior end and a part of either side, and the lower half may be more or less encrusted with sand and shell fragments. The four-lobed apertures are both anterior, placed on long siphons, moderately far apart and turned away from one another (fig. 36). The colour in the preserved specimens is dull milky white, becoming pale yellow in places; it was of a reddish tint when alive, and traces of pink are still to be seen in some specimens, especially at the branchial and atrial siphons.

The *Test* is of a soft leathery texture, much wrinkled on the outer surface, smooth and glistening on the inner and white in section. It is mostly from 1 to 3 millims. in thickness, but may be thickened at the posterior end up to nearly 3 centims.

The *Mantle* is rather thin and weak over the viscera, soft but opaque and muscular on the anterior half of the body and very muscular on the siphons (fig. 37). It bristles with minute calcareous spicules in all parts, which renders it rather easily torn, and very unpleasant to manipulate.

The *Branchial Sac* has nine wide folds on each side. They converge to the œsophageal opening.

The *Dorsal Lamina* is represented by a series of about 20 short curved pointed tentacular languets.

The *Tentacles* are of three sizes. There are about eight large and much branched, alternating with others half the size, while a variable number of much smaller ones occur between. If a little more regular the formula would be eight large, eight

medium, and sixteen small, but the latter are not all present and the large and medium ones may vary from six to nine each.

The *Dorsal Tubercle* is large, prominent and hemispherical. It is marked with two spiral coils (fig. 38).

Localities: – (1) Five specimens were trawled at Station XIX. in northern part of Palk Bay, depth $4\frac{1}{2}$ to 8 fathoms; (2) one at Station I., off Negombo, 12 to 20 fathoms; and (3) one is labelled "Gulf of Manaar."

The largest specimen measures 9 centims. × 6 centims. × 3 centims., the two next each 5 centims. × 5 centims. × 2 centims., the next 3 centims. × 3 centims. × 1 centim., and the smallest 2 centims. × 1·5 centims. × 1 centim. These specimens agree fairly well in most characteristics with *Rhabdocynthia pallida* (HELLER) to which v. DRASCHE'S *Cynthia mauritiana* is closely related. These species are described as having only eight branchial folds, while the present one has nine. They also differ in the dorsal tubercle, the tentacles and other details, but these are all points subject to individual variation. The large branchial and atrial siphons have strong sphincter muscles, from under the lower edge of which very strong radial muscle bundles emerge. There are about 16 of these on each side at the atrial sphincter, and about 30 on each side at the branchial. The arrangement of these muscles is seen in fig. 37. Large lobed gonads are present on both sides, and show through the mantle as a number of rounded masses (fig. 39), rather different in appearance from the figures of *Rh. pallida* given by SLUITER and MICHAELSEN; however, I believe the difference is only due to stages of growth. The ova occupy the wide central part of the mass, and the spermatic cæca are grouped in clumps around the margin.

I thought at first, because of the red colour when alive, that this species might be SLUITER'S *Cynthia rosea*—which is a *Rhabdocynthia*—but a closer examination showed that it differed from that form in the details of the branchial sac, in the form of the dorsal languets, and the dorsal tubercle, as well as in the shape of the body and relative positions of the apertures. However, the two species are closely related, and it is a question whether fuller knowledge of both in the future will enable us to unite them.

This large Ascidian is said by the natives to be characteristic of the West Cheval Paar, but is also found at other places in the Gulf of Manaar.

Rhabdocynthia ceylonica, n. sp.—Plate III., figs. 1 to 19.

External Appearance.—Body of globular or ellipsoidal form, covered with clear pale yellow sand and small shell fragments, except around the apertures. Siphons prominent, the atrial rather the longer; both on anterior end, and connected by a ridge of test, which, like the siphons themselves, is bare of sand (fig. 3). The lobes of the apertures are marked with white radial lines (see figs. 18, 19); size about 2 centims. × 1·5 centims.

Test thin, transparent; containing branched vessels with knobs and also spicules.

Mantle transparent except for the muscle bundles and the spicules. There is a loose felt-work of fine spicules all over the surface, and the mantle is flecked with white on the siphons. There are four lines of white pigment dots down the inside of each siphon (fig. 18).

Branchial Sac with seven folds on each side, the most ventrally placed one on the left side being very slight. The transverse vessels are of three sizes (fig. 7), in the wider of which spicules are found. There are six internal bars on a fold, and the meshes, between the folds, are square and contain about six stigmata. They are crossed and sometimes interrupted by the third order of transverse vessel.

Dorsal Lamina represented by moderate-sized triangular languets (fig. 17).

Tentacles.—About ten large, branched, with smaller ones between (figs. 10, 11). Another specimen showed eleven larger and eleven smaller alternately placed, with occasional still smaller ones (figs. 10, 11).

Dorsal Tubercle large, but simple; horse-shoe shaped, with both ends turned in (figs. 8, 9). One specimen showed, as an abnormality, a double tubercle (fig. 16).

The *Alimentary Canal* forms a long open loop on the left side of the body.

Gonads are present on both sides. Each is hermaphrodite, the spermatic cæca being arranged around the masses of ova.

Localities:—(1) Alentura Paar, Station LVIII., 26 fathoms, two specimens; (2) Station I., off Negombo, 12 to 20 fathoms, two specimens (of a reddish colour when alive); (3) Station IV., off Karkopani, 6 to 9 fathoms, one specimen (1·6 centims. × 1·2 centims., with atrial siphons 6 millims. long, and very little sand); (4) Galle Bay (from basket hung to a buoy), one specimen about 1 centim. long (the fixation and growth must have taken place entirely between April 17 and May 9; (5) Station LIII., 10 miles north of Cheval Paar, 7 to 8 fathoms, four specimens; (6) Trincomalee, 11th February, one small specimen; (7) Aripu Reef, 18th March, one small specimen. The two specimens from Alentura Paar are entered in our field-notes as "Two transparent Cynthias with red edges to the siphons and sand on the test." These two specimens were preserved in strong formol and are still very soft and transparent. The inside of the test is in a gelatinous condition, is continuous with the mantle, and adheres strongly to it round the anterior end. In dissecting, the animal is as soft and gelatinous as when alive.

A sandy *Rhabdocynthia* is a novelty, and if we consider the allied species of *Cynthia* we find that this species differs from *Cynthia arenosa*, HRDN., in the details of the branchial sac and in the spicules and the dorsal tubercle.

The spicules are of the usual *Rhabdocynthia* type, and are sufficiently illustrated in the figures (figs. 12 to 15). I have considered the possibility of this form, the largest specimen of which is only 2·5 centims. in length, being a young stage of *Rh. pallida* (HELLER) which attains a size of 9 centims.; but there are in the collection small specimens of the latter species measuring only 2 centims. across, and these have already the characters of the adult and are entirely different from *Rh. ceylonica* of

corresponding size. It differs from *Rhabdocynthia tenuis*, HRDN., in the external appearance and in the dorsal tubercle.

Microcosmus manaarensis, n. sp.—Plate II., figs. 23 to 31.

External Appearance.—A rough mass of sand, foraminifera, and shell fragments, stiff but brittle, with more or less of the anterior end and two short siphons projecting, and having the posterior end thickly covered and prolonged into root-like sandy wisps (figs. 23, 24). Size about 2 centims. in diameter; colour varying with the sand. The siphons may be echinated with slight projections.

Test white in section, leathery, but more or less completely buried in the crust of sand, which may extend to nearly 1 centim. in thickness. The inside of the test is quite firm and glistening, and is marked by the impress of the strong muscle bundles of the mantle. The outside of the test bears numerous hair-like processes which run out into the sandy coating (fig. 25).

Mantle yellowish brown and very strong. The siphons are long and muscular (fig. 28). Atrial aperture bilobed on inside (fig. 27).

Branchial Sac with six folds on each side. There are five bars on a fold and three in the interspace. The meshes are elongated transversely and contain about 10 stigmata. There are seven narrower transverse vessels between each pair of very much wider; narrow horizontal membranes cross some meshes (fig. 31).

Dorsal Lamina a plain membrane.

Tentacles six large and six smaller alternately, much branched (fig. 29).

Dorsal Tubercle small, cordate in outline, with the opening anterior and both horns turned in (fig. 30).

The peripharyngeal bands have a characteristic undulating course.

Localities:—(1) Station LIII., 10 miles north of Cheval Paar, 7 to 8 fathoms, two specimens which differ in the amount of sand they bear; (2) Station XLVI., off Mount Lavinia, 30 fathoms, two specimens; (3) "Gulf of Manaar," three specimens; (4) Trincomalee, Station XXIV., 30 fathoms, three specimens.

This species differs from those already known from eastern seas, such as *M. helleri*, *M. ternatanus*, *M. propinquus*, *M. affinis*, and *M. ramsayi*, and also from the two new species found by the "Siboga" expedition, *M. hæmisphærium* and *M. arenaceus*. The last-named species is a sand-covered form like the present one, but differs notably in the dorsal tubercle, which is broken up into several separate openings, and in having papillæ on the horizontal membranes at each longitudinal vessel.

The species to which the present seems most nearly allied is *M. gleba*, TRAUSTEDT, from the Pacific; a species which differs in having 10 large tentacles and in some details of the branchial sac.

This species forms dark sandy balls about the size of a walnut, and in most specimens the fringe of sandy rootlets at the posterior end is conspicuous (fig. 23).

The coating of sand is so thick and dense that in some cases it can be peeled off

the test as a coherent shell, so as to give the appearance of one test lying within another (fig. 26). In life the siphons are very long, and their terminations are yellow tubes, marked with dark red bands.

Eleven young fishes were found in the peribranchial cavity of one specimen from off Mount Lavinia.

Microcosmus longitubis, n. sp.—Plate II., figs. 32 to 35.

External Appearance.—The body is ovate, with two very long siphons diverging from the narrow anterior end. It is encrusted with sand and shell fragments, which are especially large and thickly placed on the rounded posterior half of the body (fig. 32). Size, about 5 centims. from the end of the branchial siphon and 3 centims. across the wider posterior part of the body.

Test stiff and leathery, ranging up to 2 millims. in thickness. Greyish white and glistening on the inner surface, white in section. There are numerous large vessels, and there are long branched processes on the surface to which the sand is attached.

Mantle strong, very muscular (fig. 33), the body with the test removed having the appearance of a ball of tightly wound threads, with the two very long siphons protruding. The branchial is the longer and straighter, the atrial being curved dorsally.

Branchial Sac with six folds on each side; rather narrower than those of the last species, and having four or five bars, but none in the interspace. There are five to seven narrow transverse vessels between the very much wider ones. The meshes may extend the whole distance from fold to fold and then contain 20 to 24 stigmata, or may be interrupted by irregular oblique or curved vessels (fig. 34). The stigmata are rather short and neatly shaped.

Dorsal Lamina a plain membrane.

Tentacles branched. There are 10 of large size, some rather larger than others, and a few very small additional ones placed between.

Dorsal Tubercle having a symmetrical semicircular outline, with both ends lightly rolled in (fig. 35).

Locality :—Tampalakam, Trincomalee.

Cynthia transversaria, Sluiter, var. **manaarensis**, nov.—Plate III., figs. 20 to 24.

External Appearance.—Shape ovate or pyriform, with widely divergent prominent apertures at the narrower anterior end (fig. 20). Attached by posterior half of left side. Surface even, but closely encrusted with fine sand grains all over. Siphon square in section, with slight ridges at the angles. Colour, greyish-yellow; size, 3 centims. × 1·5 centims. × 1 centim.

Test thin, but tough and stiffened by the embedded sand; a little thickened at posterior end; dirty white on inside and in section.

Mantle yellow; strongly muscular on the long siphons and the anterior half of body, less so over the viscera and posteriorly (fig. 21).

Branchial Sac with six well-formed folds on each side converging to the œsophageal aperture. Stigmata running transversely in place of longitudinally, so as to cross the internal bars at right angles (fig. 24). There are thus no meshes, and the wide vessels between the rows of stigmata run more or less parallel with the folds in place of across them. The folds have six to eight bars, and the interspaces two or three each. The connecting ducts supporting the bars sometimes come from the transverse vessels, and are sometimes interstigmatic.

Dorsal Lamina represented by a row of closely placed small tentacular languets (fig. 22), smaller and more distant in front, rather stouter and much closer together further back.

Tentacles compound, of three sizes: six of the largest, six of the second, and twelve of the smallest size.

Dorsal Tubercle having a simple ovate slit (fig. 22) placed in the mouth of a deep triangular peritubercular area.

Alimentary Canal forming a long narrow loop placed transversely to the body (fig. 21); stomach ridged longitudinally.

Gonads one on each side (fig. 21), long irregularly lobed yellow bodies, lying transversely in a curve concave anteriorly.

Locality:—Station LIV., in the north part of the Gulf of Manaar, 10 fathoms.

This form is certainly closely related to Sluiter's *Halocynthia transversaria* from Ki Island and Banda, in the Malay Archipelago, but differs in so many minor points from the "Siboga" specimens that I place it as a distinct variety, "*manaarensis*." The Ceylon specimen agrees with Sluiter's description in the remarkable transverse arrangement of the stigmata and in the general characters of the tentacles and the dorsal tubercle, but differs in the following points:—The sandy investment of the body is much slighter and the shape is different, allowing the two siphons to stand out prominently (Plate III., fig. 20). The interspaces between the branchial folds have only two or three internal longitudinal bars each (fig. 24) in place of seven as in Sluiter's specimens. The examination of further material will, no doubt, show whether these differences are bridged by intermediate conditions, or whether they are maintained as the characters of two closely related species.

The living specimen is described in our field-notes as "milky grey, mottled and streaked with dull purple; thin coating of hairs with mud on surface."

Cynthia crinitistellata, Herdman.—Plate III., figs. 25 to 29.

One small specimen from Station IV., off Karkopani, 6 to 9 fathoms. Size, 1·4 centims. in length × 1·5 centims. in breadth × 7 millims.

This species is only known from Port Jackson.

The five specimens in the collection of the Australian Museum, Sydney, were

described in 1899.* The present little specimen from Ceylon (fig. 25) agrees perfectly in external characters, including the spines and the remarkable stellate hairs (figs. 26 to 29), forming a fine down over the surface of the test, with the Australian specimens.

Cynthia aripuensis, n. sp.—Plate III., figs. 30 to 39.

External Appearance.—Body of irregularly globular or pyriform shape, with the narrower anterior end cleft into the two long crumpled siphons. The branchial siphon is especially long (fig. 31). Attached by the posterior end. Surface corrugated. Colour, creamy yellow, browner in places; some specimens have a pink tinge. Size of a large specimen, 4 centims. × 2·5 centims. × 1·5 centims.

Test leathery and tough, up to 2 millims. in thickness, wrinkled on the outer surface, creamy yellow, smooth and glistening on the inside, white in section. The invaginated test lining the siphons bears slender sharp-pointed scales (fig. 33).

Mantle strong, opaque anteriorly, more membranous and transparent posteriorly, of a yellowish colour becoming red on the siphons. Strong muscle bundles radiate from the bases of the siphons (fig. 35).

Branchial Sac with six folds on each side. About nine to twelve internal bars on the fold, and four to six rows of meshes in the interspace. There are three smaller transverse vessels between each pair of much larger ones (fig. 32). The mesh is transversely elongated, contains about six rather small stigmata, and is divided by a horizontal membrane. Parasitic Copepoda are present in the branchial sac.

Dorsal Lamina represented by closely placed long tentacular languets (fig. 37).

Tentacles large, much branched, and closely placed; about 18 larger ones and the same number of very much smaller ones placed so that the bases touch (fig. 36).

Dorsal Tubercle simple, ovate in outline, with the opening anterior or lateral, and the horns coiled slightly inwards (figs. 38, 39).

Gonads large, yellow; present on both sides, in a double row of about 20 masses.

Locality:—(1) Aripu coral reef, shallow water, about a dozen specimens; (2) "Gulf of Manaar," four specimens; (3) Station LXVI., off Mutwal Island, 10 to 35 fathoms, three specimens; (4) Station IV., off Karkopani, 6 to 9 fathoms, two specimens.

This is probably a fairly common *Cynthia* in the Gulf of Manaar, as a number of specimens were obtained while wading on Aripu coral reef, of which about a dozen were preserved. The specimens dredged off Mutwal Island are certainly the same species, although the shape is a little longer and less globular (fig. 30). That slight difference may well be due to the place of attachment or to the accidents of preservation. The internal organisation is the same as in the Aripu specimens.

This species recalls SLUITER'S *Halocynthia polycarpa* from the "Siboga" expedition, but differs notably in the tentacles and the dorsal tubercle, and in the details of the branchial sac. From ROULE'S *H. corallina* this species also differs in several

* 'Descriptive Catalogue (No. XVII.) of Tunicata in Australian Museum,' Sydney, 1899, p. 34.

particulars. The spines of the branchial aperture, moreover, are characteristic (figs. 33 and 34).

Cynthia lanka, n. sp.—Plate IV., figs. 1 to 13.

External Appearance.—A sandy mass of ovoid form, with a narrower anterior end raised to form a slight ridge, at the extremities of which the apertures are placed (figs. 3 and 4). Size, 2·5 centims. × 2 centims.

Test closely encrusted with a layer of sand, not thick.

Mantle thin and transparent, with prominent muscular siphons, atrial the longer (figs. 5, 6). Branchial siphon lined by closely placed, sharp-pointed spines (fig. 12).

Branchial Sac with six folds on each side. There are five to seven internal bars on a fold and about three to five rows of meshes in each interspace. The meshes are square, contain each four stigmata, and may be crossed by a narrow horizontal membrane (fig. 11).

Dorsal Lamina in the form of short curved tentacular languets (fig. 10).

Tentacles much branched.

Dorsal Tubercle small, widely cordate, with the opening anterior (figs. 7 to 9).

Gonads a double row on each side opening into a zig-zag duct (figs 5, 6, 13).

Localities:—(1) Station XLIX., south-west of Cheval Paar, 8½ fathoms, one specimen; (2) Station LXVI., off Mutwal Island, 10 to 35 fathoms, two specimens; (3) Station XIX., Palk Bay, 8 fathoms, five specimens; (4) Station XXIV., Outer Bay, Trincomalee, 24 to 46 fathoms, half a dozen specimens.

This sandy *Cynthia*, to which I have given the ancient native name of Ceylon, seems undescribed. The appearance of the alimentary canal and gonads, as seen when the test is removed (figs. 5 and 6), recall *Cynthia jacatrensis*, SLUITER, from Malaysia, *C. molguloides*, from Australia, and VAN NAME's var. *munita* of TRAUSTEDT's West Indian *C. riiseana*, from Bermuda, but our Ceylon species differs from all of these. Notwithstanding the very complete armature of spines lining the branchial siphon (fig. 12), there were several parasitic Copepoda in the branchial sac.

The zig-zag arrangement of the oviduct connecting the gonads is a conspicuous feature. Fig. 13 shows a portion of the organ enlarged.

FAMILY: STYELIDÆ.

Styela lapidosa, n. sp.—Plate V., figs. 7 to 15.

External Appearance.—Of oblong, ovate form, apparently unattached, with the anterior end rather the wider, and covered closely and uniformly with coarse quartz sand grains (figs. 7 to 9). Apertures both on the rounded anterior end, not prominent, inconspicuous. Surface and colour due to the sand; size, 2·3 centims. long by 1·2 centims. wide.

Test thin, but stiffened by the sand, brittle, transparent on inner surface letting the sand grains show through distinctly.

Mantle thin, transparent and very slightly muscular, except on the two short siphons, where there are strong sphincters.

Branchial Sac with four slight but well-formed folds on each side. About six bars on a fold, and four to six rows of meshes in the wide interspaces (fig. 14). The meshes are square, contain each about five rather large closely placed regular stigmata, and are divided horizontally by a membrane. Narrower and wider transverse vessels alternate.

Dorsal Lamina is a corrugated membrane.

Tentacles of three sizes (fig. 15), eight of the largest, eight of the second, and sixteen of the smallest.

Dorsal Tubercle with a simple but wide funnel-shaped opening (fig. 15). Peri-tubercular area narrow.

Alimentary Canal with a wide intestinal loop (fig. 10); stomach ridged.

Gonads a curved, slightly lobed organ on each side of the body, having the ovary along the middle and the spermatic cæca on the edges.

Localities :—(1) Stations LIII. and LIV., in north part of Gulf of Manaar, 4 to 40 fathoms, a few specimens; (2) Station XLVI., off Mount Lavinia, 30 fathoms, four specimens; (3) Station XXIV., Outer Bay, Trincomalee, 24 to 46 fathoms, a dozen specimens; (4) Station XLIX., South Periya Paar, 13 fathoms, eight specimens; (5) Station LXIII., West of Periya Paar, 17 to 55 fathoms, nine specimens.

This seems to be a common species around Ceylon, as a number of specimens were found at localities on both sides of the island.

The appearance of the tentacles and of the dorsal tubercle (fig. 15) is very suggestive of a Polystyelid or a Botryllid.

The apertures are striped with yellow and red when alive. The stiff brittle sandy test and the large curved gonad on each side are characteristic features.

Styela areolata, HELLER—Plate IV., figs. 24 to 33.

It is necessary to re-describe this species, with figures, since HELLER'S description was very brief and no illustrations have been published showing the structure.

External Appearance.—Body ovate, attached by a few slight tag-like processes at the posterior end. Siphons slight, both on dorsal edge, apertures small, cross-slit. Surface uneven, but smooth. Colour, milky white. A little sand adhering towards the posterior end (fig. 24). Size about 2 centims. × 1·5 centims.

Test thin and semi-transparent, smooth on the surface except where encrusted with sand. The test may be reduced to a very thin layer in the middle of the posterior end, and has thickened edges round the area of attachment. There are vessels in the test.

Mantle semi-transparent, allowing the viscera to show through. The muscle bundles are very fine.

Branchial Sac with four wide folds on each side. There are five internal bars on a fold and three rows of meshes in the interspace. The transverse vessels are of three orders. The meshes are elongated transversely and contain eight or nine stigmata, and may be crossed by a narrow horizontal membrane (fig. 33).

Tentacles simple, numerous, large and small alternately.

Dorsal Lamina a plain membrane.

Dorsal Tubercle having a simple rather angular horse-shoe curve with a wide opening. The ends turn slightly either in or out (figs. 31 and 32).

Alimentary Canal large, stomach ridged longitudinally, intestine wide, forming a close loop.

Gonads four to six on the right side, one or two on the left (figs. 27 to 30).

Localities:—(1) Aripu coral reef, four specimens; (2) Station LIII., 10 miles north of Cheval Paar, 7 to 8 fathoms, four specimens; (3) Station I., off Negombo, 12 to 20 fathoms, four specimens (one of these is almost bare of sand and another is more than half covered with reddish brown large sand grains so as to closely resemble in appearance the sandy *Rhabdocynthia*, *Rh. ceylonica*, found in the same neighbourhood); (4) Station X., East of Cheval Paar, 6 fathoms, three specimens—one large (fig. 26) with half a dozen young pearl oysters adhering, almost free from sand, test milk-white and corrugated at anterior end, one smaller half-covered, and one wholly covered with red-brown sand except the two siphons and a strong ridge of test connecting them; (5) Station LIV., North end of Gulf of Manaar, half a dozen small specimens from 1 centim. to 2·5 centims. in length; (6) Station XLIX., South end of Periya Paar, 13 fathoms., one specimen.

Although Heller's description is very brief, the name he gives the species inappropriate, and his single figure of the external appearance not characteristic, still I have no doubt that his specimen, brought from Ceylon by Schmarda, belonged to the same species as those I have now before me. The milk-white colour and the long tubular gonads, about four on the right side and two on the left, are characteristic features mentioned by Heller which render the identification fairly certain. He does not mention the sand which is usually present on the surface, and the areolation of which he makes so much is by no means always present. However, feeling confident that it is the same species that is in question, I have re-described and figured Heller's *S. areolata* from the specimens in the present collection.

The few prominent tubular gonads on each side of the body in this species recall the arrangement seen in Sluiter's eastern species *Styela oligocarpa* and *Styela sedata*; but in other points of structure and in external appearance the Ceylon specimen differs from both of these, although they must be regarded as allied forms.

Styela ascidioides, n. sp.—Plate V., figs. 27 to 32.

External Appearance.—Body oblong, erect, attached by a short narrow stalk or posterior thickening. Branchial aperture on anterior end, atrial on dorsal edge, one-

third of the way back. Both apertures very regularly four-lobed (fig. 28). Colour, grey. Size, 2·5 centims. × 1 centim.

Test cartilaginous, full of bladder cells (fig. 30) and pigment cells (blue, black, red and yellow).

Mantle having a fine network of fibres running in all directions.

Branchial Sac large and loosely disposed, with four folds on each side. Transverse vessels rather wide, of three sizes. Internal bars wide, ribbon-like; from eight to sixteen on a fold and six to eight in the interspace. Meshes square, containing each four or five stigmata (fig. 32).

Tentacles large and closely placed, about 30 (fig. 31).

Dorsal Lamina a plain membrane.

Dorsal Tubercle small and inconspicuous, placed close to the tentacles (fig. 31).

Nerve Ganglion and neural gland forming a conspicuous spot.

Alimentary Canal forming a narrow loop at posterior end of left side (fig. 29); stomach simple, ovate.

Gonads nine prominent yellow masses on each side, closely packed, pyriform, with ducts directed towards the atrial aperture.

Locality:—Station LVIII., Alentura Paar, Gulf of Manaar, 9 to 26 fathoms.

The cartilaginous test, with its *Ascidia*-like structure, and the minute dorsal tubercle placed close to the tentacles, are special features of this species.

Styela pigmentata, n. sp.—Plate VI., figs. 24 to 26.

External Appearance.—Of quadrate shape, broader than long, attached by a wide base (fig. 24); somewhat encrusted and covered with growths of weed, &c., but not stiff. Colour dark; size, about 3 centims. × 3 centims.

Test leathery, but rather soft and flexible, with *Crenella* embedded in its thickness; yellowish grey and glistening on the inside.

Mantle soft, and opaque dark brown; not muscular; inner surface pigmented yellow and white.

Branchial Sac pigmented with yellow and white, with four well-marked folds on each side. There are at least six internal bars on a fold and three in the interspace. The meshes contain each eight stigmata (fig. 25).

Endostyle with very wide, white pigmented lips.

Dorsal Lamina a plain membrane.

Tentacles pigmented yellow and white.

Dorsal Tubercle represented by a diffused triangular area covered with minute pores (fig. 26).

Locality:—Jokkenpiddi Paar, Gulf of Manaar, 8½ to 10 fathoms.

Polycarpa aurata, Quoy and Gaimard—Plate V., figs. 1 to 6.

External Appearance.—Shape oblong, erect, with both apertures at anterior end, sessile, not distant (fig. 1). Attached by posterior end, and having a little encrusting

sand or shell fragments; surface more or less corrugated. Colour from dull brownish grey to blackish brown; size, 2·3 centims. × 1·3 centims. × 0·5 centim.

Test leathery, but rather soft; dark grey in the interior, and pigmented with minute black spots to varying degrees having numerous pigmented vessels (fig. 2).

Mantle moderately thick, but not very muscular, of a dark colour (fig. 3) and having the gonads embedded in it; apertures and siphons black.

Branchial Sac nearly black in colour, with four large closely placed folds on each side; six internal bars on a fold, and three in each interspace (fig. 6).

Dorsal Lamina a narrow plain membrane.

Tentacles about 30, all of same size.

Dorsal Tubercle an indefinite spongy mass with many small apertures (fig. 5).

Alimentary Canal small, intestine slight.

Gonads, 10 to 12 round polycarps, sunk in the mantle on each side.

Localities:—(1) Station IV., off Karkopani, 6 to 9 fathoms, one specimen; (2) Station XLVI., off Mount Lavinia, 30 fathoms, one specimen; (3) Gulf of Manaar, three specimens adhering in a clump.

It is possible that these Ceylon specimens of this widely distributed and somewhat variable species ought to be separated off as a distinct variety. As they have some distinct characteristics, I have drawn up the above description. All the specimens have more brown and black pigmentation than I have seen in the species before, which gives them a "tanned" appearance both inside and out, while the apertures are practically black. In all these characters they agree with HELLER'S *Polycarpa nigricans*, from Mauritius, which, however, is described as having a basal stalk and root-like processes which are not present in the Ceylon specimen. It is possible that HELLER'S species is the same as QUOY and GAIMARD'S, in which case *aurata* remains as the name of the species and *nigricans* becomes a synonym.

Polycarpa mutilans, n. sp.—Plate IV., figs. 34 to 44.

External Appearance.—Shape oblong or trapezoidal, with a narrow anterior end and a sloping dorsal edge. Apertures both moderately prominent, but not on long siphons; branchial anterior and atrial about the middle of the dorsal edge (fig. 38). Surface uneven and corrugated. Colour, dirty greyish yellow; size, 3·5 centims. × 2·2 centims. × 1·5 centims.

Test tough and leathery, very irregular on outer surface, smooth on inner, white in section.

Mantle moderately muscular, with fine, but numerous, bundles of fibres running both longitudinally and transversely.

Branchial Sac, when present, with four folds on each side. The fold has about six internal bars and there are about three in each interspace. The meshes are nearly square and contain each four to six long narrow stigmata (fig. 37).

Dorsal Lamina a narrow plain membrane (fig. 37).

Tentacles large and numerous, all one size, bases touching, about 80 in all (fig. 39).

Dorsal Tubercle simple, with an anterior opening and the horns rolled slightly inwards in one specimen (fig. 44) and turned outwards in another (fig. 43).

Alimentary Canal with an open loop and a closely ridged stomach; but it may, like the branchial sac, be completely absent.

Gonads.—A row of about 14 yellow sausage-shaped polycarps on the right side of the body and fewer on the left. Many endocarps on both sides.

Locality:—Station LIV., in north part of Gulf of Manaar, 4 to 40 fathoms, three specimens.

Of the three specimens of this species obtained together at the one spot, two are in an interesting condition. The specimen shown in fig. 38, and from which the above description has been drawn up, is perfect and normal in all its organs; but the other two which, externally, seem as well grown and as complete (see fig. 34), were found on dissection to have no alimentary canal and no branchial sac (see fig. 35).

SLUITER, in 1885, described a single specimen of a *Styela* which he found at Billiton, in the Malay Archipelago, under the name *Styeloides abranchiata*, as a new species belonging to a new genus because of the absence of branchial sac and alimentary canal. As it was scarcely possible to believe that such could be the normal condition of the species, in my 'Revised Classification of the Tunicata' (p. 578), in 1891, I expressed some doubt and suggested that SLUITER's specimen was an individual abnormality.

In 1895, SLUITER, in his "Report on the Tunicata of the Semon Expedition," described a new species, *Styela solvens* (SEMON, 'Forschungsreisen,' Bd. v., p. 182), in which, out of three specimens found at Amboyna, the branchial sac was absent in two and the intestine in all. This observation caused SLUITER to relinquish his genus *Styeloides*, and suggest that in the species of *Styela* in question the branchial sac, &c., might become lost as a normal process. The following year, however, WILLEY, in his "Letters from New Guinea" ('Quart. Journ. Micr. Sci.,' 1896, p. 161), described the ejection of the viscera which he had actually observed in a species of *Styela* which he, following SLUITER, named *Styeloides eviscerans*. SLUITER refers further to the three mutilated species, *Styela abranchiata*, *St. solvens*, and *St. eviscerans* in his paper on WEBER's South African Tunicata ('Zoolog. Jahrb.,' 1898), and raises the question whether regeneration can be in progress in such cases. Finally, two additional specimens of *Styela abranchiata*, both also in the mutilated condition, were obtained by the "Siboga" expedition.

The condition of affairs in the three specimens from Ceylon, which I am now describing as *Styela mutilans*, confirms the impression I expressed in the 'Revised Classification' in 1891, and upon which agreement seems now to be general.

The Ceylon specimens do not belong to any of the previously described species of SLUITER or WILLEY. They differ from all in various particulars, and belong clearly to the genus *Polycarpa*; but here is a case where, if the first specimen which I

examined had alone been found, or even if the first and second only had been known, the species might have been described as destitute of branchial sac, stomach, and intestine. And yet the third example, which there is no reason to think belongs to a different species, shows a perfectly normal structure. I have no doubt that specimens one and two have lost their alimentary tract. From WILLEY'S observations it seems possible for an Ascidian by a powerful contraction of the mantle under some abnormal conditions to perform evisceration and get rid of the entire free portion of the canal, from the peripharyngeal bands to the anus, and that seems to be the best explanation of all such abranchiate specimens.

The tentacles remain, as they are firmly attached to the muscular body-wall, and they are alike in all the three Ceylon specimens. Fig. 39 shows the appearance of a stained preparation of a tentacle, where (*a*) indicates a band of ciliated columnar epithelium, the rest of the surface being covered with squamous cells, while (*b*) is a tract of solid connective tissue, along the convex edge, which stains a bright red with picro-carmine, and is probably skeletal in function. The rest of the interior contains lacunæ with many blood corpuscles (*c*).

The only difference that is apparent between the normal and the abranchiate specimens is that the latter have a more abundant crop of endocarps projecting from the body-wall (fig. 36), and as these are individually larger (figs. 40 to 42) and contain lacunæ in connection with those of the mantle outside (fig. 36), and show many blood corpuscles in their interior, I would suggest that this greater development of these thin-walled vascular processes has taken place in order to compensate for the absence of the branchial sac by promoting respiration. SLUITER, in his original mutilated specimen, *Styela abranchiata*, found that the mantle was thickened and highly vascular, and he recognised that its condition compensated for the absence of the normal respiratory organ. In *Styela solvens*, however, no unusual development of the mantle is described. Whether any nutrition can be effected by amœboid cells in the body-wall absorbing particles brought into the single large cavity by the branchial and atrial apertures, and whether the animal can maintain life for long in this abnormal state, there is no evidence to show. Experimental work on eviscerated specimens would be necessary to determine such points.

If the animal is able to carry on existence in this mutilated condition, two physiological points arise: the one as to respiration and the circulation of the blood, the other as to digestion and nutrition. The heart and the chief blood-vessels have gone with the other loose viscera. The abundant thin-walled endocarps containing blood lacunæ and projecting freely into the sea-water in the peribranchial cavity no doubt perform respiration effectively, and it is possible that they pulsate like the ampullæ in the test of *Botryllus* and so keep the blood in movement. The other possibility is that contraction of the muscles in the mantle squeezes the blood irregularly from place to place in the body-wall and so prevents stagnation.

In regard to nutrition, it seems possible that amœboid cells in the connective-tissue

of the body-wall, and from the blood lacunæ, might take up nutrient particles brought in by the water and ingest and digest them in an intracellular manner. Although, in the absence of the branchial sac, there can be no strong current through the animal, still the muscles of the mantle, and especially the sphincters of the siphons, will no doubt suffice to draw in and to expel supplies of water, and the cilia of the peripharyngeal bands and of the tentacles will be able to separate out, guide, and retain the diatoms and other nutrient particles.

If the food can be brought within reach of the amœbocytes and ingested, there is probably no difficulty in regard to digestion. Such cells are probably able to form the necessary ferments and effect solution and absorption of the food. It is known that ordinary tissue-cells in even a higher animal contain erepsin, and possibly other ferments, and can exercise a slow proteolytic action. It seems highly probable* that leucocytes and other undifferentiated cells—especially in plastic organisms like the Ascidians, where tissue differentiation is not highly marked—contain amylolytic and proteolytic ferments sufficing for intra-cellular digestion of microscopic organic food.

Polycarpa sluiteri, n. sp.—Plate V., figs. 16 to 21.

External Appearance.—Shape pyriform or oblong with a narrower anterior end terminated by the branchial aperture. Atrial aperture half-way down dorsal edge (fig. 16). Surface rough, corrugated, having a few shell fragments and other foreign bodies adhering. Attached by posterior end and parts of left side. Colour, very dark grey, nearly black in places. Size, 3 centims. × 2 centims. × 1·5 centims.

Test tough and leathery, rough and irregular on outer surface, quite opaque, smooth, but rather dark on the inner surface and grey in section.

Mantle dark coloured, not thick, with strong muscular siphons.

Branchial Sac with four wide folds on each side, with about nine or ten bars in the folds and five rows of stigmata in the interspace. Transverse vessels alternately larger and smaller. Meshes square, containing each seven or eight rather long narrow stigmata (fig. 21).

Dorsal Lamina a plain membrane with no ribs and no marginal teeth.

Tentacles of two sizes, six very large and six much smaller.

Dorsal Tubercle rather small and slight, in a deep narrow triangular peritubercular area, with the opening anterior and the horns turned one in and one out but not coiled (fig. 17). Two other tubercles are shown in figs. 18 and 19.

Gonads numerous; from 15 to 20, dull yellow, sausage-shaped polycarps on each side of the body, arranged roughly in a row facing the atrial aperture (fig. 20). A few dark-coloured endocarps projecting between them.

Locality:—(1) Station V., Chilaw Paar, 10 fathoms, three specimens; (2) Aripu coral reef, one specimen.

This species in some respects resembles *Polycarpa mutilans*, but differs from it so

* In the light of recent work by Ascoli and Marescii, Vernon, Rulot, and the Ladisls.

completely in the tentacles, as well as in other points, that there can be no question of their distinctness. It is, however, exceedingly like the form described by SLUITER from Billiton (Malay) under the heading "*Styela elata* (HELLER) (?)," in 1885. MICHAELSEN, in his revision of HELLER'S types, dealt with *Polycarpa elata*, HELLER, assured us that SLUITER'S form does not belong to that species and suggested the name *P. seriata* for it. The agreement of the Ceylon form with SLUITER'S description extends to the gonads, the branchial sac and the dorsal tubercle, but the tentacles are not alike, and there are other differences in detail, so I consider it safest to give the above full description of my specimens under the name *P. sluiteri*. In the dorsal tubercle this species closely resembles *Styela ambonensis*, SLUIT., of the "Siboga" expedition.

Polycarpa chalmersi, n. sp.—Plate V., figs. 22 to 26.

External Appearance.—Shape rounded or quadrate, somewhat flattened; attached to lumps of coral or to the tubes of the large Foraminifera *Ramulina herdmani* in such a way that the anterior end, dorsal edge, and a large part of both sides is exposed (fig. 23). Apertures sessile, cross-slit when closed, opening out into short siphons with wide square ends when alive. Surface somewhat creased, produced into roughened lobes about the anterior end. Colour, red and grey when alive, siphons streaked with red and white; dull bluish-grey in spirit. Size, 1·8 centims. × 1·3 centims. × 6 millims.

Test thin, but tough and leathery, thickening to over 1 millim. on the roughened anterior end.

Mantle very thin, closely adherent to test. Muscle bands very fine, forming a close net-work.

Branchial Sac with four well-marked folds on each side. There are about nine internal bars on a fold, and about three rows of meshes in each interspace (fig. 24). The meshes are nearly square and contain half a dozen stigmata. There are three narrower transverse vessels between each pair of larger ones.

Dorsal Lamina a plain narrow membrane.

Tentacles long and slender, of two sizes, about 30 in all.

Dorsal Tubercle small and simple, in the form of a narrow U-shaped slit, with the opening anterior and placed in a small triangular peritubercular area (fig. 25).

Alimentary Canal rather short and wide, stomach ridged.

Gonads small hermaphrodite bottle-shaped polycarps (fig. 26), 10 or 12 on each side.

Localities:—(1) Station XLI., 12 miles south of Galle, 100 fathoms, several specimens; (2) Station XXXV., Galle Bay, 7 fathoms, four specimens on a bit of old coral (fig. 22).

These specimens show the change which may occur of an Ascidian which is bright red in life into a bluish-grey colour when preserved in alcohol. I have noticed this so frequently in both simple and compound Ascidians that when, in a preserved

collection, one comes upon specimens showing this opaque dull bluish-grey appearance, there is at least a strong probability that the colour in life was red. I have pleasure in dedicating this interesting little species to my friend Dr. A. J. CHALMERS, Professor in the Medical College at Colombo.

Polycarpa alentura, n. sp.—Plate V., figs. 33 to 37.

External Appearance.—Body conical or dome-shaped (fig. 33), attached by a broad base at the posterior end. Apertures on the narrow anterior end, not projecting, inconspicuous. Colour, yellowish grey; size, 2 centims. × 1·5 centims.

Test smooth, slightly wrinkled, leathery.

Mantle thin, pigmented, having a very fine felting of delicate muscle fibres.

Branchial Sac with four wide folds on each side, about 15 internal bars on a fold, and about seven rows of meshes in the interspace. Transverse vessels of several sizes; meshes narrow, containing three to five stigmata each (fig. 37); the stigmata are crossed by a narrow horizontal membrane.

Dorsal Lamina with a few slight denticulations at the anterior end (fig. 35), behind that a plain membrane.

Tentacles rather short and irregular, 14 in number, differing a little in size.

Dorsal Tubercle curiously shaped (fig. 36) with the aperture posterior, one end turned in and the other out.

Alimentary Canal with a widely open intestinal loop; stomach yellow-brown, striated longitudinally (fig. 34).

Gonads consisting of a few polycarps only. Large numbers of small endocarps engorged with opaque yellow blood corpuscles project from the body-wall.

Locality:—Station LVIII., off Alentura Paar, 9 to 26 fathoms, one specimen.

Polycarpa decipiens, n. sp.—Plate VI., figs. 33 to 39.

External Appearance.—Body rounded and covered with sand like a *Molgula*, unattached. Both siphons on the anterior end, but rather distant (fig. 33); size, about 1 centim. across.

Test thin, but covered with a soft, rather loose, coating of sand.

Mantle thin and transparent.

Branchial Sac with four slight folds on each side (fig. 34). Each fold has only three or four internal bars, and there are no bars in the interspaces. Between the endostyle and the 1st fold are 16 stigmata, between the 1st and 2nd 8, between the 2nd and 3rd 8, between the 3rd and 4th 10, and between the 4th and the dorsal lamina 14. The stigmata are shown in fig. 35.

The *Dorsal Lamina* is a plain membrane.

The *Tentacles* are about 20 large, not all quite the same size, and intermediate very much smaller ones.

Dorsal Tubercle simple, ovate, with the opening slightly on one side and the horns turned in (fig. 36).

Alimentary Canal forming an open loop; intestine short and wide.

Gonads flattened, ovate, hermaphrodite polycarps, placed on both sides of the mantle, 10 on left side and 12 on right (fig. 37). The oviduct and vas deferens are shown in fig. 38, and part of the testes in fig. 39.

Locality:—Station LIII., 10 miles north of Cheval Paar, 9 fathoms, one specimen.

Polycarpa palkensis, n. sp.—Plate VI., figs. 5 to 8.

External Appearance.—An ovate sandy mass, attached by a large area to a dead chank shell. Apertures inconspicuous, at opposite ends of the body. Size about 2 centims. in length by 1·5 centims. in breadth.

Test stiff, entirely encrusted with sand to a thickness of about 5 millims.

Mantle opaque. When the test is removed the body is of fusiform shape with the two prominent siphons almost at opposite extremities and directed away from one another (fig. 5).

Branchial Sac with four folds on each side; about six bars on each fold, and three rows of meshes in the interspace. The transverse vessels are of two sizes (fig. 7), the meshes are transversely elongated, with six or seven stigmata in each.

Dorsal Lamina a very narrow plain membrane.

Tentacles rather long, about 30, not all same length.

Dorsal Tubercle rather large and complicated (fig. 6). The opening is anterior, both horns are rolled inwards and one is much larger than the other.

Alimentary Canal forming a small canary-yellow compact mass.

Gonads, numerous elongate ovate polycarps (fig. 8), about 20 on each side.

Locality:—Trawled at Station XIX., in Palk Bay, 8 fathoms, one specimen.

This species shows some resemblance to SLUITER's *Styela floccosa* obtained by the "Siboga," but differs in the gonads and other details of structure.

Polycarpa colletti, n. sp.—Plate VI., figs. 1 to 4.

External Appearance.—Shape erect, cylindrical, almost rod-like; attached by the posterior end with the branchial aperture on the anterior end and the atrial about half-way down the dorsal edge (fig. 1). Surface finely creased or corrugated. Colour, creamy white; size, 2·5 centims. × 8 millims.

Test leathery.

Mantle strong, opaque, yellow, closely adhering to the test.

Branchial Sac with four low, rounded folds (fig. 3) on each side. Each fold has 14 or more closely placed bars, and there are two bars in the interspace separating a very wide central row of meshes from two lateral narrower rows. The wider mesh contains about eight stigmata and the narrower half that number. The transverse vessels are

of three sizes, arranged with regularity, and there may also be narrow horizontal membranes crossing the stigmata (fig. 4).

Dorsal Lamina a low plain ridge.

Tentacles of two sizes, about 20 larger and the same number of smaller, placed alternately (fig. 2).

Dorsal Tubercle a large circular area with a small opening at one side, around it is a swollen spongy area.

Locality :—Station XLIX., South-west of Cheval Paar, 13 fathoms, one specimen.

This species is named in honour of the late Mr. OLIVER COLLETT, an excellent naturalist in Ceylon, much interested in the pearl oyster investigation.

Polycarpa willisi, n. sp.—Plate VI., figs. 9 to 15.

External Appearance.—Elongated ovate, almost fusiform, with the large siphons at opposite extremities of the body (fig. 9); each opening very distinctly four-lobed and surrounded by a square rim (fig. 11). Surface sandy; size, 1·4 centims. in length.

Test thin, sparsely covered with adhering sand.

Mantle opaque, pigmented with orange and pale yellow; siphons long (fig. 10).

Branchial Sac with four folds on each side. About five bars on each fold, and two rows of meshes between. The stigmata (fig. 12) are very short, and rather irregular; they form ovate or rounded holes from two to four in a mesh.

Dorsal Lamina a narrow plain membrane.

Tentacles of three sizes arranged regularly (fig. 13), there being eight large, eight medium, and sixteen smaller between.

Dorsal Tubercle a rounded mass with no distinct horns (fig. 13).

Alimentary Canal a narrow, short loop; stomach smooth, and coloured yellow.

Gonads about 12 elongated orange-brown polycarps on each side of the endostyle (fig. 14), and a number of more rounded pale lemon-yellow endocarps (fig 15) scattered between. Each gonad has the ova in the centre and the testes placed around.

Locality :—Station LXII., Periya Paar, 13 fathoms, three specimens of about the same size.

The interior of the body is much pigmented with opaque yellow, especially the alimentary canal, the endocarps, and the mantle.

I have pleasure in naming this species after my friend Dr. J. C. WILLIS, Director of the Royal Botanic Gardens at Peradeniya, Ceylon.

Polycarpa twynami, n. sp.—Plate VI., figs. 27 to 32.

External Appearance.—Body erect, oblong, attached by the rather narrower posterior end. Branchial aperture anterior atrial a little way along dorsal edge, both sessile (fig. 27). Surface somewhat corrugated and wrinkled. Colour, brown; size, 3·5 centims. × 1·5 centims.

Test leathery but soft, and irregularly thickened, brown inside.

Mantle opaque brown, adhering closely to the test.

Branchial Sac of a dark brown colour, with four folds on each side. About six internal bars on the fold and eight rows of stigmata in the interspace. There are three or four narrower transverse vessels between much wider ones. The meshes are nearly square, with 3 or 4 stigmata in each (fig. 31).

Dorsal Lamina a plain membrane.

Tentacles at least 30 in number, large, with occasional smaller ones (fig. 32).

Dorsal Tubercle simple, horse-shoe-shaped, with the opening anterior and the horns not coiled (fig. 29).

Alimentary Canal dark brown, anus surrounded by about eight finger-like processes (fig. 28).

Gonads, numerous polycarps and endocarps, all of a very dark brown colour, partly sunk in mantle.

Locality.—(1) Jokkenpiddi Paar, Gulf of Manaar, 10 fathoms, two specimens; (2) Station LXIX., Chilaw Paar, 11 fathoms, one specimen.

Two larger and several smaller specimens of a *Crenella* were embedded in one test. This species is dedicated to Sir WILLIAM TWYNAM, of Jaffna.

Polycarpa manaarensis, n. sp.—Plate VI., figs. 16 to 22.

External Appearance.—Somewhat quadrate in shape, with the apertures on two equal projections, giving the anterior end a cleft appearance (fig. 16). Surface corrugated and encrusted with sand and shell fragments. Colour, dark brown on surface, with a pearly lustre inside; size about 4 centims. × 3·5 centims.

Test leathery, hard and stiff. In section it is seen that the sand-grains are embedded in, as well as attached to, the test.

Mantle thick, opaque, ruddy brown.

Branchial Sac with four folds on each side. There are about nine bars on a fold and six in the interspace. The transverse vessels are of three orders with still smaller ones crossing the stigmata frequently and irregularly (fig. 22). The meshes are nearly square and have about four stigmata each.

Dorsal Lamina a narrow plain fold (fig. 21).

Tentacles placed a long way in front of the peripharyngeal band (figs. 17, 20); about 40, larger and smaller alternately.

Dorsal Tubercle a widely open horse-shoe, with the opening anterior and the horns not turned in (figs. 18, 19). Pre-branchial zone pigmented.

Alimentary Canal a wide loop, stomach globular.

Gonads, many large rounded polycarps sunk in the thick mantle.

Locality:—(1) Station LXII., Periya Paar, 13 fathoms, one specimen; (2) Station LXVI., off Mutwal Island, 10 to 35 fathoms, one specimen; (3) Jokkenpiddi Paar, Gulf of Manaar, 10 fathoms, one specimen.

Specimens of *Synalphæus comatulorum* were found in either the branchial sac or the atrium of all the specimens.

Polycarpa, sp.—Plate VI., fig. 23.

External Appearance.—Body oblong-ovate with a dorsal projection; posterior end pointed; branchial aperture on anterior end, atrial on dorsal edge about one-third of the way back. Surface covered with sand and shell fragments. Size, about 6 centims. × 3 centims.

The single specimen dredged at Tampalakam, Trincomalee, on February 11, is found on examination to be in bad condition, so that the internal structure cannot now be determined. It was probably dead when collected. The test is quite stiff and is strengthened by embedded sand. The mantle is thin and appears to have few muscle bundles. The branchial sac is slight, but beyond the four folds on each side little can be made out. There are numerous small polycarps scattered over the body-wall.

It is impossible to identify this with any described form, and the condition prevents it from being described as new. But it may be useful to place on record that a *Polycarpa* with these general characters (fig. 23) was found at Trincomalee.

Family: POLYSTYELIDÆ.

Some writers, led by Michaelsen, have of recent years substituted a new term "Polyzoidæ" for the above well-known family name Polystyelidæ. I cannot follow them. Even if it be proved that Lesson's "*Polyzoa opuntia*" is the same animal that Cunningham described later as *Goodsiria coccinea*, it by no means follows that because *Goodsiria* becomes *Polyzoa*, Polystyelidæ must become Polyzoidæ. The type-genus of the family Polystyelidæ is, of course, not *Goodsiria*, but is *Polystyela*. But it is premature to change even the generic name. It is by no means certain that Lesson's "*Polyzoa*" belonged to this family. His description would apply at least as well to a species of *Colella*, such as one resembling the "*Aplidium pedunculatum*" of Quoy and Gaimard, which is found in the same neighbourhood (Straits of Magellan and Falkland Islands) as to *Goodsiria coccinea*.

Michaelsen has recently asked* why Heller's term Polycynthiæ should not have priority over Polystyelidæ as the name of the family or sub-family. The answer is simply because Heller did not propose that term as the title of a family or sub-family, nor did anyone else, until Michaelsen, in 1904. According to the 'International Rules of Zoological Nomenclature' (Paris, 1905): "Art. 4. The name of a family is formed by adding the ending *idæ*, the name of a sub-family by adding *inæ*, to the root of the name of its type-genus." Heller did not do that. He formed no family or sub-family. He merely remarked that the group Cynthiæ fell into simple and compound forms (Monocynthiæ and Polycynthiæ). There was no question here of naming or defining a family or a sub-family. No family for this group of genera existed previous to 1886. In that year, in the 'Report on the "Challenger" Tunicata,' Part II., I formed and defined the new family Polystyelidæ, choosing as

* 'Deutsche Tiefsee-Expedition, 1898–1899,' Bd. vii., 1904.

my type-genus *Polystyela*, GIARD, and naming the new family in strict accordance with the rules of nomenclature. After the definition I added: "I form this family for a very interesting little group of Ascidians, the position of which is difficult to determine. I regard them as Compound Ascidians which are allied to the Cynthiidæ amongst Simple Ascidians, and have been evolved from the sub-family Styelinæ." I then gave an outline of the history of the genera which I considered would find their place along with *Polystyela* in the family. The family was properly constituted in 1886, and the name cannot be altered until the name of the type-genus (*Polystyela*) is changed. If MICHAELSEN can prove that LESSON'S "*Polyzoa opuntia*" is the same as GIARD'S *Polystyela lemirri*,* then *Polystyela* will become a synonym of *Polyzoa* and the family name will change to Polyzoidæ, or, if it be regarded as a sub-family, to Polyzoinæ—but not till then. In the meantime, if it is placed as a sub-family of Cynthiidæ the name of the sub-family must be Polystyelinæ.

I may add that in the 'International Rules for Nomenclature,' now generally recognised and followed, there is no direction that in forming a new family the oldest generic title within the bounding line is to be selected as the type and give its name to the family. The oldest genus may be quite unsuitable for such a purpose as it may be an aberrant form very far from typical of the family. Surely it is only common sense that it should be left to the founder of a new family to choose as the type-genus that central form or assemblage of species which seems to him best to typify the new group which he is defining.

So far as to the family name—now let me add a few remarks as to some generic designations formed recently.

MICHAELSEN, in 1900, expressed his dissatisfaction with the definitions of the existing genera in this family, and introduced a new generic term, "*Alloeocarpa*," of a provisional nature (he says†: "Dieser neue Name kann nur als provisorisch angesehen werden") for those species which have a certain character of reproductive organs. But he adds: "Als Typus der Gattung *Alloeocarpa*, MCHLSN., mag *A. incrustans* (HERDMAN) (= *Synstyela incrustans*, HERDMAN) gelten." He does not sub-divide the old genus and does not retain any portion under the old name. He merely substitutes a new name because he wishes to emphasize a new character. Surely a better course would have been, if he finds that my *Synstyela incrustans* will serve as a type of what he desires to put forward, to add the new characters (if necessary) to the definition of the genus, retaining the old name *Synstyela*. As a matter of fact, the unisexual character of the polycarps was described and figured in the case of *Synstyela incrustans* in the '"Challenger" Report' (1886), and in all probability holds for other species of *Synstyela*. It would be simple to restrict the

* MICHAELSEN has suggested ('Mitteil. Naturh. Mus. Hamburg,' xxi., 1904) that GIARD'S genus possibly does not belong to the Polystyelidæ, but I find no basis in fact for this idea.

† "Die holosomen Ascidien des magalhaensisch-südgeorgischen Gebietes"; in 'Zoologica,' Bd. xii., Heft 31; Stuttgart, 1900.

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genus to such forms. I prefer, therefore, to retain the old generic title in that sense and to add the word "unisexual" before "polycarps" in the definition. MICHAELSEN'S *Gynandrocarpa*, as he first defined it, would then be the corresponding genus containing those species which have hermaphrodite polycarps. More recently ('Mitth. Naturh. Mus. Hamburg,' XXI.) MICHAELSEN has introduced still further generic sub-divisions of *Gynandrocarpa* based upon details of arrangement of the reproductive organs which seem to me to be of only specific value. If similar details were to be recognised in the genera *Styela* and *Polycarpa* almost every species would become a separate genus.

Gynandrocarpa nigricans, SLUITER.

This is a very dark coloured species which the "Siboga" found at the Island Sarassa, in Malaysia, at a depth of 16 fathoms. Our Ceylon specimens were from Talaivillu Paar, in the Gulf of Manaar, where we obtained a number of colonies from 6 centims. × 3 centims. downwards, in size, growing over coral and shell fragments. The ascidiozooids are very closely placed, there being little or no common test except at the edges of the colony. The general appearance of the animal when alive is black and white, the parts that are not deeply pigmented being transparent.

The arrangement of the vessels in the branchial sac and other points in the internal structure agree with SLUITER'S description. The darkly pigmented blood channels in the marginal parts of the colony are a remarkable feature in this species.

Gynandrocarpa (Eusynstyela) imthurni, n. sp.—Pl. VII., figs. 1 to 9; Pl. IX., fig. 4.

Colony encrusting, forming a thin sheet 1 millim. to 2 millims. in thickness (Plate VII., figs. 1 to 3), and over 9 centims. × 7 centims. in greatest extent (Plate IX., fig. 4).

Ascidiozooids from 6 millims. × 3 millims. on the surface down to 1 millim. in diameter, much flattened from above downwards, so as to form at most slight rounded elevations on the free surface. Ascidiozooids not quite closely placed, leaving some spaces of free test between. Colour (in alcohol) a dull slate-blue, pinkish-red when alive; the test nearly white, with a slight pearly lustre.

Mantle moderately muscular, not pigmented, with well-marked siphons. The atrial siphon has about 20 very delicate tentacles at its base (fig. 7) and there are also some convoluted thread-like outgrowths from the mantle hanging into the peribranchial space.

Branchial Sac with four well-marked folds on each side, with four to six internal bars on each (Pl. VII., fig. 4). The dorsal interspace has one bar, close to the first fold, the next interspace has one, the next two have each two bars, and the ventral interspace has no bar dividing its row of eight or nine stigmata. Most of the meshes contain four or five stigmata each (fig. 4).

Dorsal Lamina a plain narrow membrane.

Tentacles 20 to 22 in number, of two sizes, placed a little irregularly (fig. 5). The tentacles have large swellings at their bases, and the interior of the branchial siphon is marked out into rectangular areas by slight depressions.

Dorsal Tubercle of small size, horse-shoe-shaped (fig. 6).

Gonads hermaphrodite, about 12 on left side of endostyle and six on right. Each gonad has ova in the centre and two testes, one on each side (figs. 8 and 9).

Locality:—Station LXIX., outer Chilaw Paar, 8 to 11 fathoms; along with large colonies of *Leptoclinum*.

This is a handsome species which, from its hermaphrodite gonads, belongs to the genus *Gynandrocarpa* and differs in internal structure from all the described species. It belongs to that section which MICHAELSEN would separate as the genus *Eusynstyela*, and is allied to SLUITER'S two species *Gynandrocarpa maxima* and *G. latericius*, both obtained in Malaysian seas by the "Siboga" expedition. From *G. maxima* our species differs in the smaller size of the ascidiozooids, in the arrangement of the longitudinal bars of the branchial sac and in having fewer tentacles. From *G. latericius* it differs in the details of the branchial sac (see fig. 4), and also in the dorsal tubercle (fig. 6), which is more like that of *G. maxima*. In the tentacles our form agrees with *G. latericius*, and it possesses also those curious long, coiled, thread-like outgrowths from the mantle (fig. 7) to which SLUITER has drawn attention. In fact, the Ceylon species, while possessing a characteristic branchial sac of its own, is in other characters intermediate between the two "Siboga" species. It differs also in details of branchial sac, dorsal tubercle, tentacles, &c., from both the species of *Eusynstyela* described by MICHAELSEN, viz., *E. tincta* (VAN NAME) from Bermuda, and *E. hartmeyeri* from the Red Sea, Gulf of Suez, and African coast.

I have great pleasure in dedicating this interesting form to my friend Sir EVERARD IM THURN, K.C.M.G., who was Colonial Secretary and Lieut.-Governor of Ceylon at the time of my expedition, and who did much to encourage and promote scientific work in the colony.

Other species of Polystyelidæ have been found in far eastern seas and also in the southern part of the Indian Ocean, on the Agulhas bank, but none of these are closely related to the present species.

My "Field-notes" contain the following record as to the colour of this species when alive:—"March 20th, 1902, on outer Chilaw Paar, masses of coral and calcareous tubes covered with colonies of *Leptoclinum* (white, pink, dark neutral tint, &c.), and also a large colony of a Polystyelid of a pink or pale-crushed strawberry tint over the general surface with red apertures and a few red dots between the apertures; between the ascidiozooids the test has a slight bluish-grey tint."

Diandrocarpa brakenhielmi, MICHLSN., var. **ceylonica**, n.—Plate VII., figs. 10 to 18.

There are several colonies of a beautiful transparent Polystyelid from the Gulf of Manaar which, from the condition of its gonads, falls, according to MICHAELSEN'S system

('Mitth. Naturh. Mus., Hamburg,' 1904), into the genus *Diandrocarpa*, VAN NAME, and agrees fairly well in details of structure with the species *D. brakenhielmi*, MICHAELSEN. It shows a single hermaphrodite gonad (fig. 12) on each side of the body, and the spermatic sacs are deeply cleft into lobes (fig. 15). There are, however, some points of difference. There are only about 12 folds in the stomach-wall, certainly not so many as 14 or 15, the ducts from the spermatic cæca are certainly longer than MICHAELSEN represents, and, finally, the Ceylon species appears to be more transparent and does not in life, at least, show the bluish grey and other colours noted in the described forms of *D. brakenhielmi*. I do not attach much importance to the last point, since it is probable that MICHAELSEN'S specimens from the Berlin and Hamburg Museums were preserved colonies which had lost their transparency and changed their colour. And as I find that individuals vary somewhat in the folds of the stomach wall, in the proportions of the tentacles, and in other details of structure, I think it best to refer this to the described species with which it closely agrees, calling it the Ceylon variety and figuring its peculiarities. I have specimens in the collection from three localities, and my field-notes in regard to two of these are as follows:—

(1) North end of Periya Paar, Station LXII., 12 fathoms.—"(?) Polystyelid on young pearl oyster shell, translucent grey with lemon-yellow pigmentation, especially along a line (? endostyle) between the apertures, and also around the atrial siphon. Line of red around the edge of each aperture. Under low power of microscope surface is seen to have a reticulum of yellow, pale-blue and red-brown lines which are sinuses filled with pigment corpuscles."

(2) Cheval Paar, 6 fathoms, several colonies.—"A very thin transparent (?) Polystyelid with large ascidiozooids up to 4 millims. long, with very conspicuous branchial sac because the vessels are all engorged with coloured corpuscles. One colony covers a large area in the interior of an old pearl oyster shell and allows the nacre to show through distinctly. Ascidiozooids slightly grey, test between transparent, with a few meandering coloured lines which are vessels."

The third locality is—Attached to oyster cages suspended from the ship on the Cheval Paar; about 20 colonies ranging from 1 centim. × 1 centim. to 7 centims. × 6 centims. over all.

These specimens, although differing a little in appearance, are clearly the same species, and figs. 10 to 18, on Plate VII., show the leading points in structure. There are 10 to 12 rows of stigmata in the branchial sac, and the transverse vessels are very conspicuous from being filled with coloured corpuscles. The vessels in the test, and especially in the marginal parts of the colony, are a conspicuous feature (figs. 11 and 17). There are 12 oral tentacles of three orders, which show, however, some variation in arrangement (figs. 14 and 18). They may be 1, 3, 2, 3, 1, &c., or 1, 3, 3, 3, 1, 3, 2, 3, 3, 3, 2, 3, or 1, 3, 3, 2, 3, 3, 1, &c. There are about 20 much

more delicate atrial tentacles (fig. 18) which have not been previously noticed. Fig. 13 shows the alimentary canal and fig. 15 the gonads.

In examining a very simple Polystyelid such as this, with no folds in the branchial sac, one cannot but be struck with the resemblance not merely to the Styelidæ and to the Botryllidæ, which has often been insisted upon, but also to such Clavelinidæ as the genus *Ecteinascidia.* The fact is, that the Polystyelids are an annectant group, and such simple forms as *Diandrocarpa* lead on from the more advanced Clavelinids (such as SLUITER'S *Ecteinascidia nexa*) to the Botryllids and the Styelids.

FAMILY: BOTRYLLIDÆ.

Botryllus ater, n. sp.—Plate VII., figs. 19 and 20.

Colony a small irregular, encrusting patch from the oyster cages on the Cheval Paar.

Test clear and transparent, crowded with terminal knobs in its marginal part.

Ascidiozooids small, and especially narrow; pigmented very darkly and having the branchial aperture so black that it appears to the eye as a distinct dot upon the outer end of the ascidiozooid. From five to ten ascidiozooids in a system.

Mantle and *Branchial Sac* densely crowded with dark pigment.

Botrylloides chevalense, n. sp.—Plate VII., figs. 21 to 24.

Colony thin and encrusting, of irregular form; six colonies range from 3 centims. × 1 centim. to 5 centims. × 3 centims.; of a red colour (in formol), varying from pale brick red to purple.

Ascidiozooids, measuring 1·5 millims. × 1 millim., arranged in elliptical or linear, rarely branching systems (fig. 21).

Branchial Sac richly pigmented, and having about 10 rows of stigmata (fig. 23).

Test clear and transparent, but having a large number of terminal knobs of vessels in its marginal part (fig. 22).

Tentacles of two sizes (fig. 24), four larger and four smaller.

Locality:—Attached to pearl oysters from the oyster cages suspended from the ship while on the Cheval Paar.

Botrylloides nigrum, n. sp.—Plate VII., fig. 25.

Colony small smooth glossy black patches encrusting the branches of *Colella arenosa.* Systems forming a net-work of branching lines (fig. 25).

Test very tough on surface, deeply pigmented.

Mantle with longitudinal muscles only.

Branchial Sac with many rows of stigmata.

Locality:—South of Modragam Paar, 6 fathoms.

FAMILY: DISTOMIDÆ.

Colella arenosa, n. sp.—Plate VII., figs. 26 to 29.

Colony consisting of branched masses (fig. 27) growing through sponges and other attached organisms, and partly encrusted with the black *Botrylloides niger*. The base and larger branches are thickly covered with attached and embedded sand. The twigs terminate in rounded knobs of a pale violet colour and nearly free from sand (fig. 26). Some of the larger masses measure 6 centims. × 3 centims. over all; the branches are 2 millims. to 3 millims. in diameter; the knobs are about 4 millims. across the free end.

Ascidiozooids placed in the free ends of the knobs, from 12 to 20 in each, and having the usual structure of the genus (fig. 26).

The violet pigmentation of the test in these specimens is found, even in the branches, under the sandy coating.

Locality:—South of Modragam Paar, 6 fathoms; half a dozen colonies and fragments. There are also three colonies from Station LXIX., Chilaw Paar, 8 to 11 fathoms, which have exactly the appearance and structure of the above except that the violet pigment is absent, and the free ends of the knobs are dark grey.

Cystodytes ceylonensis, n. sp.—Plate VIII., figs. 23 to 25.

About a dozen small, rounded, or lobed (fig. 23), encrusting colonies belonging to the genus *Cystodytes* were obtained from Talaivillu Paar, 8 fathoms. They were of a bright red purple colour when alive, and range in size from 1 centim. across to 2 centims. × 1·5 centims. The thickness from the attached to the free surface is 5 millims. The colour now, after preservation in alcohol, is a dark greyish brown, and the ascidiozooids show through indistinctly as dirty yellow streaks. Each ascidiozooid has the usual thick calcareous envelope (fig. 24), and the component discs are marked with delicate radial striæ (fig. 25).

A group of several little similar brown colonies, which are indistinguishable from the above in the preserved condition, were dredged at the south-east end of Ceylon on February 13. The colour when alive was not noted.

In structure this form closely resembles *Cystodytes philippinensis*, HRDN., obtained by the "Challenger" expedition, but differs in colour and in having the discs relatively thinner and more finely striated.

FAMILY: POLYCLINIDÆ.

? Polyclinum nigrum, HRDN.

A large black colony and some smaller pieces from the pearl banks, Gulf of Manaar, measuring about 6 centims. × 6 centims. and extending up to 1·5 centims. in thickness, may be this Australian species. Our colony has a very smooth shining black surface, and occurs growing over masses of sponges, &c. The surface is marked by

large circular depressions, about 1·5 millims. across, which probably correspond to the ends of the ascidiozooids, but no distinguishable remains of the latter are visible on dissection. It is probable that the colony was either dead or regenerating at the time when it was collected.

Amaroucium sp. ?—Plate VIII., fig. 43.

There are several small colonies from the Gulf of Manaar which probably belong to this or one of the allied Polyclinid genera. The largest colony is shown in fig. 43. They are mostly in poor condition, or have lost the ascidiozooids, and consequently I only refer to them for the purpose of stating that a species belonging to this group occurs in the locality.

Psammaplidium ceylonicum, n. sp.—Plate VIII., figs. 8 to 11, and Plate IX., fig. 9.

Colony a large and very sandy mass of rather flabellate form, with vertical walls and buttresses, recalling the appearance of some sponges (see Plate IX., fig. 9); surface lobed, uneven and rough, divided up into small areas (Plate VIII., fig. 11) and very thickly encrusted with sand; size, 15 centims. × 10 centims. × 8 centims.

Ascidiozooids small for the size of the colony, scarcely 3 millims. in length, and less than 1 millim. in greatest breadth; abdomen and post-abdomen very slender, thorax wide (Plate VIII., fig. 8).

Test densely crowded with sand-grains, having the ascidiozooids arranged in its superficial layer only (fig. 10).

Mantle with both longitudinal and transverse muscle bands on the thorax; over the abdomen the longitudinal bands coalesce into two strong bundles which course along the post-abdomen and terminate in two projecting points (fig. 8), which show strong echinations under a high power (fig. 9).

Alimentary Canal long and slender (fig. 8); stomach folded longitudinally.

Tailed larvæ are present in the colony (taken March 7).

Locality:—Station LIV., in north part of Gulf of Manaar, 10 to 30 fathoms.

There are several smaller colonies, and fragments, from various parts of the Gulf of Manaar which are indistinguishable in structure from this species, although they may differ somewhat in appearance on account of the colour or size or amount of the sand-grains taken up by the test.

Psammaplidium aurantiacum, n. sp.—Plate VIII., figs. 2 to 6, and Plate IX., fig. 8.

Colony a large rounded mass (Plate IX., fig. 8), slightly lobed, with a smooth surface only slightly sandy; of a dull orange colour; size, 9 centims. × 7 centims. × 4 centims.

Ascidiozooids up to 3 millims. in length, and rather less than 1 millim. in greatest breadth; dull yellow in colour, embedded in a clear orange-grey test. The anterior ends of the ascidiozooids as seen on the surface are grey.

Test with a few sand-grains scattered on the surface and others embedded in the superficial layers (fig. 2); numerous pigment cells present which give the orange colour to the colony (figs. 3 and 4).

Mantle with strong muscle bundles running both longitudinally and transversely, and causing considerable corrugation of the thorax (fig. 5).

Alimentary Canal forming a large loop, stomach with longitudinal folds, rectum wide (fig. 6).

Locality :—Cheval Paar, 7 fathoms, one colony.

There are two other colonies in the collection from the Gulf of Manaar which, notwithstanding their rather different appearance, I am inclined to refer also to this species. The one is a grey *Psammaplidium* measuring 7 centims. × 5 centims. × $1\frac{1}{2}$ centims., rounded, smooth, and only slightly sandy. The test is grey and transparent, allowing the more opaque grey ascidiozooids to show through, and only differing from the test of *Ps. aurantiacum*, as described above, in the absence of pigment cells.

The other colony is a hemispherical mass, 4 centims. × 4 centims. × 2 centims., of grey colour, but not so transparent as the last and having a yellowish tint. The thorax, abdomen and post-abdomen are each about 1 millim. in length; there are eight large tentacles; the stigmata are small and of rounded form.

Psammaplidium, spp., A and B (? n. spp.)—Pl. VIII., fig. 7: Pl. IX., figs. 10, 11.

In addition to the two species of *Psammaplidium* described above, there are two others which may possibly be distinct from all known species, and from one another, but which I do not feel sufficiently certain of to describe from the present specimens. Both species are densely sandy, and of both one or two large colonies were found in addition to fragments.

The first form (A) is a plano-convex mass, the largest colony measuring 9 centims. × 6 centims. × 3 centims., and probably attached by the whole of the flat surface. The upper rounded surface is divided up into many lobes (Plate IX., fig. 10) which, however, are closely packed together. The mass is most closely impregnated with sand, both on the surface and throughout its depths, so as to appear on section like a consolidated mass of sand. The ascidiozooids are small, not at all abundant, and can only be separated in fragments. They show nothing unusual or specially characteristic in their structure. This colony was dredged in the Gulf of Manaar in February, 1902; and a second, measuring 6 centims. × 5 centims. × $2\frac{1}{2}$ centims., is from Station LIII., 10 miles north of Cheval Paar, 10 fathoms.

The second colony (B) measures 7 centims. × 4 centims. × 3 centims., and is irregularly lobed and produced into bars which join, leaving holes. The surface is covered with a reddish sand, formed of very fine and uniform grains of ellipsoidal shape and quite smooth, which surround the anterior ends of the ascidiozooids (Plate VIII., fig. 7). In addition to these uniform red granules, which are singularly like fæcal pellets, there are a few ordinary irregular sand-grains embedded in the test.

The ascidiozooids are very small, of a translucent grey colour, rather closely placed, and are mainly in the superficial 2 millims. This colony (fig. 11) was dredged at Station LIV., in the northern part of the Gulf of Manaar; depth, 10 to 30 fathoms.

A few other smaller *Psammaplidium* colonies were found which are too fragmentary or imperfect to describe. Some of these are from Muttuvaratu Paar (Station LIX.), 9 fathoms. Others are small sandy lobed masses with areas of black test showing at the ends of the lobes. The test is densely pigmented black, the branchial aperture is eight-lobed, and the atrial has a languet. The masses are about 3 centims. × 1 centim., and the locality is Gulf of Manaar.

Family: DIDEMNIDÆ.

Hypurgon skeati, I. Sollas—Plate VIII., fig. 1, and Plate IX., fig. 5.

This remarkable form was described by Miss I. B. J. Sollas from a specimen found at Pulau Bidang in the Malay Peninsula; and my specimen, from the pearl banks in the Gulf of Manaar, agrees sufficiently closely in detail to be referred not only to the genus but to the same species.

The single Ceylon colony measures over 8 centims. × 4 centims. between its extremes, but is spread over a slightly branched tube and some tufts of Algæ, as seen in Plate IX., fig. 5. The surface is of a warm grey-green colour; and the ascidiozooids, measuring 0·3 millim. across their free ends, are arranged in single lines on each side of the branched cloacal tubes which meander over the surface, with some few occasionally scattered between (Plate VIII., fig. 1)—a more regular arrangement than is described by Miss Sollas.

Didemnum areolatum, n. sp.—Plate VIII., figs. 26 and 27.

Colony encrusting, about 6 centims. × 4 centims. over all, of irregular shape, and 2 millims. thick; with numerous small systems of four, six, or more ascidiozooids (figs. 26), which gives the surface an areolated appearance.

Ascidiozooids of a dirty white colour, due to the calcareous spicules that surround them, while the test between is an amber brown. The branchial apertures show as conspicuous dark points. Ectodermal processes run out into the test.

Test much vacuolated in the lower part (fig. 27) and having many small pigment cells in the upper part giving the brownish colour. There are also spherical calcareous spicules which in some places become stellate with blunt rounded points, but in others are merely knobbed (fig. 27).

Tailed larvæ are present in the test (taken March 20).

Locality:—Station LXIX., Chilaw Paar, 8 to 11 fathoms.

Leptoclinum margaritiferæ, n. sp.—Plate VIII., figs. 19 to 22, and Plate IX., fig. 7.

The *Colony* is a large, moderately thick encrusting mass covering a clump of four pearl oysters (Plate IX., fig. 7). The surface is smooth and soft. The colour when

alive was greyish, mottled and streaked with black and white; now, after preservation, it is of a pale pink or crushed-strawberry tint. The size of the mass of oysters and Ascidian together is 9 centims. × 7 centims. × 6 centims. over all.

The *Ascidiozooids* are numerous all over the surface of the colony, and are usually scattered irregularly. In some places they are in double rows, or there are vacant tracts between them (see fig. 7). Common cloacal apertures are few and small. The anterior ends of the ascidiozooids are about 0·5 millim. across.

The *Test* is soft and not opaque. It is of a greyish colour with a slightly pink tint. The calcareous spicules are stellate (fig. 20), but are not very abundant. A thin layer is found on the surface, and in deeper sections they occupy the lines of test which separate the ascidiozooids (fig. 19). There is also a clump of spicules on each side of the thorax of the ascidiozooid. Rounded masses of pigment granules are also present in abundance in the test (fig. 20), as well as small branched test-cells.

The *Branchial Sac* has four rows of short rounded stigmata (fig. 22).

The *Tentacles* are short and thick, 16 in number.

The *Testis* is lobed, with the usual spiral vas deferens (fig. 21).

Locality:—Station XIX., Palk Bay, south of Mandativu, trawl, 5 fathoms.

Leptoclinum pantherinum, Sluiter.

One colony measuring 12 centims. × 6 centims. and several smaller fragments, obtained from Talaivillu Paar at a depth of 8 fathoms, appear to belong to this species. They are of a dirty cream colour streaked with brown. The colour is due to aggregations of pigment corpuscles in the test. There were fully developed tailed larvæ in the colony when collected (April 1). Another small colony was dredged at Station LXIX., Chilaw Paar, 8 to 11 fathoms.

Leptoclinum ceylonicum, n. sp.—Plate VIII., figs. 15 to 18; Plate IX., figs. 1, 2.

A number of colonies, large and small, of a white *Leptoclinum*, which occurs growing over the coarse sand and calcareous fragments of the sea-bottom both in the Gulf of Manaar and in the lagoon at Galle, are so similar in their general characters that, although they show some variation, I think it right to unite them as one species. Two somewhat divergent colonies are reproduced about half natural size, from photographs, in figs. 1 and 2 on Plate IX. Fig. 1 is a colony measuring 16 centims. × 15 centims. × 8 centims., from Station XIX., in Palk Bay, 8 fathoms; while fig. 2 is a mass of about 12 centims. × 10·5 centims. × 6 centims., of plano-convex form, from Station II., off Chilaw, 14 fathoms (the flat surface is shown). In each case those figured are samples of several other colonies, and they show well the characteristics of the species. Colonies were also obtained from the coral reef at Galle and from Aripu reef in the Gulf of Manaar.

The included coarse sand-grains and shell fragments are readily seen, especially in fig. 1, and the interior of the mass contains others which render the substance very

brittle. In macroscopic structure this species is sponge-like, there being numerous passages and spaces bounded and crossed by bars of tissue (Plate VIII., fig. 15). The walls of the deeper passages are raised up to form numerous tubercles, as shown in Plate VIII., fig. 16, which represents an optical section.

There are very few cloacal openings visible on the colony, and the ascidiozooids, which show as greyer and more translucent spots on the opaque white surface, seem quite irregularly scattered over the surface (fig. 17). They are small and numerous and have no marked characteristics. The stellate spicules are very abundant, especially near the surface, and as a result the colony has a gleaming white appearance. The rays of the spicules are short and blunt or even rounded at the end (fig. 18).

Leptoclinum ceylonicum, var. **planum**—Plate IX., fig. 4.

I place in this variety two large colonies, measuring 18 centims. × 11 centims. and 12 centims. × 12 centims., and one smaller (12 centims. × 7 centims.), which (along with a colony of *Gynandrocarpa imthurni*) is figured from a photograph (fig. 4) about half natural size. All three occur encrusting dead corals and masses of *Vermetus* tubes from Station LXIX., Chilaw Paar, depth 8 to 11 fathoms, in the Gulf of Manaar. They are very similar to the colonies of *L. ceylonicum* in structure and as seen in thin sections, but differ in forming more of a flat continuous sheet in place of lobes and bars. That difference, however, may be due to the firmer sub-stratum which they encrust. They have not quite the same gleaming white appearance, but this is a character in which parts of the same colony may differ; so I cannot consider these colonies from Station LXIX. as being of more than varietal rank.

Leptoclinum ramosum, n. sp.—Plate VIII., figs. 12 to 14, and Plate IX., fig. 3.

This species is represented by a single very large colony growing over the dead sclerobase of an Alcyonarian coral dredged just outside the pearl banks in the Gulf of Manaar. The colony measures about 20 centims. in length and is about 7 centims. across at the widest, an average width is 5 centims. The colony branches and anastomoses in a characteristic manner (Plate IX., fig. 3) so as to leave numerous spaces and passages. The branches or bars are about 5 millims. in diameter on the average. The colour is a dead milk-white. Very few cloacal openings are visible, and the ascidiozooids are not conspicuous. In most parts they are few and distant, in some few places they are more abundant and more conspicuous. The marks caused by the ascidiozooids vary in size from 0·5 millim. to 1 millim. across.

The spicules are much larger than those of the last species and are more densely packed on the surface, where they form an opaque layer even in thin sections (fig. 12), and less densely deeper down, where they frequently run in lines so as to form a reticulation (fig. 13). The rays of the spicules are much more regular (fig. 14) and more sharply pointed than in the case of the last species.

Leptoclinum viride, n. sp.—Plate VIII., figs. 28 to 33.

Colony small encrusting masses (fig. 28) covering the stems of the large zoophyte *Campanularia juncea;* extent about 3 centims. × 2 centims.; of a green colour when alive, dull white when preserved.

Test with the surface layer packed with small rounded cells containing green granules (fig. 29); deeper layer (fig. 30) contains many stellate calcareous spicules.

The surface of the colony is marked off into areas by branching grooves, along the sides of which the ascidiozooids are arranged (fig. 28). The distribution of the ascidiozooids and spicules, as seen in a surface section, is shown in fig. 33. The spicules are placed most densely between the ascidiozooids, and only sparingly over the surface in lines radiating from the branchial aperture.

Fig. 31 shows one of the round cells containing green granules highly magnified, and fig. 32 is one of the larger spicules to show the characteristically blunt points.

Locality:—Station XLIX., south of Periya Paar, 13 fathoms.

Leptoclinum, spp. (?).

In addition to the species of *Leptoclinum* described above, there are many smaller colonies and fragments in the collection which seem too indeterminate and imperfect to be identified. Some of them may be undescribed forms, but if so they are probably poor specimens which possibly do not show well some characteristics of their species. It may be worth while, however, to mention the localities of some of these colonies in order to give a more correct impression of the abundance of the genus round the coast of Ceylon.

On Chilaw Paar:—

A smooth yellow-brown *Leptoclinum.*
A snow-white solid species.
An echinated form (Plate VIII., figs. 41 and 42) with many cloacal apertures.
Also an ordinary dull white form.

On Cheval Paar:—

Small white colonies encrusting sponges.
A snow-white densely calcareous form.
Pieces of a brown *Leptoclinum.*

On Navakaddua Paar:—

Some small fragments of an ordinary white form in which the spicules are spherical, with low flat knobs in place of projecting points.

Off Negombo:—

Ordinary dull creamy-white colonies.

Off Mutwal Island, March 19:—

Mottled dark blue-black and white form.

Off Mount Lavinia, 30 fathoms:—

Ordinary white *Leptoclinum.*

On the Coral Reef, Galle:—

Fragments of white, grey, drab and dark purple Leptoclinids too small to describe satisfactorily.

Family: DIPLOSOMATIDÆ.

Diplosoma viride, n. sp.—Plate VIII., figs. 34 to 40, and Plate IX., fig. 6.

Colony rounded to elongate, moderately thick, encrusting on Algæ and Coral fragments (Plate IX., fig. 6); surface even and soft; colour, rich green; size, from 2 millims. in diameter up to 4 centims. in length × 1 centim. in breadth × nearly 1 centim. in thickness.

Ascidiozooids about 0·5 millim. across anterior end; arranged irregularly, in the smaller colonies forming a single row round the edge (Plate VIII., fig. 34).

Test having two distinct layers; the spreading margin of the colony, often drawn out into delicate processes (fig. 36) for attachment, is formed of highly vesicular test, full of bladder cells, while the deeper part in which the ascidiozooids are embedded is much denser, has no bladder cells, and is crowded with small test cells and with large spherical green bodies which give the colour to the colony.

Branchial Sac with four rows of rather small rounded stigmata (figs. 37 and 38). The transverse vessels have muscle fibres.

Tentacles six in number, all one length.

Alimentary Canal large, stomach smooth-walled, rectum conspicuous, containing three or four fæcal pellets (fig. 36).

Localities.—(1) On Coral Reef, Galle; (2) Talaivillu Paar, 8 fathoms.

The colonies of this small dark green *Diplosoma* are very abundant at both localities where they were found. On Talaivillu Paar they occur growing over broken fragments of Madrepores and other dead corals, and in the lagoon at Galle they are abundant, encrusting calcareous and other Algæ. Most of the colonies are small and rounded, but some become more elongated and form small encrusting sheets. The usual occurrence, however, is numerous small rounded colonies, closely placed, which may cover an area up to 8 centims. × 5 centims. When alive, the centre of the colony where the common cloacal aperture is placed is depressed and of a paler green colour. The zone of ascidiozooids is also paler, while the outer ring of the colony, outside the ascidiozooids, is the darkest and is usually of a very rich green colour (see fig. 40). The preserved specimens have entirely lost their colour and are now opaque white.

The green colour is due to immense numbers of small round bodies which are probably symbiotic Algæ. They have a central clear space (fig. 35), while around that is a finely granular pigmented layer. These pigmented cells are specially abundant in the outer layers of the test; they are also around the bodies of the ascidiozooids, and they extend more sparsely scattered through the loose lacunar test that occupies the centre of the colony (fig. 40). Vessels with swollen terminal knobs (fig. 36) are a conspicuous feature in the thin expanded margin of the colony.

Diplosoma crystallinum (Giard).

A number of small colonies of a grey semi-transparent *Diplosoma* which were found encrusting pearl oysters and sponges, &c., in the oyster cages suspended from the ship at the Cheval Paar, are indistinguishable from the common European *D. crystallinum*. There are long pointed lobes to the branchial siphon, the ascidiozooids have large eggs, and many tailed-larvæ are embedded in the test (taken in April). Ten colonies range from 1 centim. to 3 centims. in length.

Diplosoma, sp. (?)—Plate VIII., fig. 44.

Four small reddish-brown colonies were dredged from Muttuvaratu Paar (Station LIX.), 9 fathoms, which resemble *D. viride*, from Galle, in structure, but have pigment spherules of a different colour in the test. The colony is fixed by a small base, has overhanging edges and a flat upper surface with a little central tubercle which probably marks the position of the common cloacal aperture (fig. 44). The ascidiozooids show as dots on the surface, and in profile on the margin. The test is very tough, is vacuolated as in the case of *D. viride*, and contains many rounded pigment masses of a reddish colour.

Family: SALPIDÆ.

Salpa cylindrica, Cuvier.

Some individuals of both the solitary and the aggregated forms of this species were obtained in tow-net gatherings on the West Cheval and the Periya paars, and in Palk Bay. The solitary forms extend up to 29 millims. in length, and single members of the chain form up to 14 millims.

My "Field-notes" contain some observations on the specimens of this species taken in Palk Bay. "The body is nearly cylindrical, when alive, with projecting ridges along the sides. The 'nucleus' is marked with yellow, brown, and red. The stomach is brown with yellow cæca around it. When swimming, the tubular orifices are drawn in and shot out again almost simultaneously. They certainly do not alternate. If not quite simultaneous the order is:—oral, atrial, long pause, oral, &c. The aggregated forms are arranged longitudinally in chains and are iridescent when in movement, and look pale blue on a black background."

Salpa runcinata-fusiformis, Cham.-Cuv.

Considerable numbers of both the solitary and the aggregated forms were found along with the last species both in Palk Bay and also on the West Cheval and Periya paars. The solitary form reaches 30 millims. and the aggregated 24 millims.

In some hauls of the tow-net taken off Negombo at Station I. some small specimens of both the solitary and the aggregated form (reaching only 9 millims. or 10 millims.) were obtained.

Salpa democratica-mucronata, Forsk.

Some of the aggregated form were taken in the bay at Galle in February. Many of both solitary and aggregated forms were obtained off Negombo at Station I. with the last species. A few occurred also in Palk Bay.

Family: DOLIOLIDÆ.

Doliolum sp. (?).

Unfortunately the specimens of *Doliolum* are no longer in the collection, but the genus was noted as being present at the following localities :—

On West Cheval and Periya paars (" nurse-form with broad bands").

Galle Harbour, February 17 (" small adult form").

The genus can therefore be recorded from both ends of the island.

Family: APPENDICULARIIDÆ.

Oikopleura sp. (?).

A small species of *Oikopleura*, with no noticeable characteristic features, occurred :—(1) off Negombo, Station I.—many small individuals ; and (2) Galle Bay, February 17.

One of the specimens obtained at Galle was larger than the rest, had a large flat pointed tail bearing two crimson spots near the end. There is some violet pigment in the branchial sac and a yellow spot at the anterior end of the endostyle. We do not yet know the permanence and the value of these pigments in classification. Dr. A. Willey got bright yellow and brilliant blue specimens in New Britain, and Mr. E. T. Browne found an *Oikopleura* with crimson pigmentation at Valencia, in Ireland. All that I can do at present is to record that the genus *Oikopleura* (probably two species) occurs round the coast of Ceylon.

EXPLANATION OF PLATES.

PLATE I.

Figs. 1 and 2. *Perophora hornelli*, n. sp. Nat. size.
Fig. 3. Part of the stolon. × 40.
Figs. 4 and 5. Parts of the branchial sac. × 40.
Fig. 6. The atrial aperture, from the inside. × 40.
,, 7. The alimentary canal. × 20.
,, 8. Tentacles, dorsal tubercle, languets. × 40.
,, 9. *Ecteinascidia sluiteri*, n. sp. × 2.
,, 10. Part of the stolon. × 5.
,, 11. The dorsal edge, to show muscles. × 10.
,, 12. Part of the branchial sac. × 40.
,, 13. The tentacles, dorsal tubercle, &c. × 40.
,, 14. The alimentary canal. × 10.
,, 15. *Ecteinascidia solida*, n. sp. Nat. size.
,, 16. Part of the branchial sac. × 40.
,, 17. The dorsal languets. × 40.
,, 18. *Ecteinascidia thurstoni*, Hrdn. Nat. size.
,, 19. The largest ascidiozooid a little enlarged.
,, 20. The tentacles. × 40.
,, 21. The dorsal languets. × 40.
,, 22. The gonads. × 20.
Fig. 23. Branchial and atrial siphons, from interior. × 10.
Figs. 24, 25 and 26. *Rhodosoma ceylonicum*, n. sp. Nat. size.
Fig. 27. Anterior end opened to show siphons.
,, 28. The short lateral muscle bundles.
,, 29. The branchial siphon and tentacles. × 40.
,, 30. The branchial sac. × 40.
,, 31. Connecting ducts and imperfect bars. × 300.
,, 32. The dorsal languets. × 40.
,, 33. The dorsal tubercle. × 40.
,, 34. *Ascidia polytrema*, n. sp. Nat. size.
,, 35. Dorsal tubercle and neighbouring parts. × 40.
,, 36. Transverse muscles of the mantle. × 40.
,, 37. The branchial sac. × 40.
,, 38. *Ascidia mikrenterica*, Sluit., the alimentary canal. × 3.
,, 39. Part of the branchial sac. × 40.

PLATE II.

Fig. 1. *Ascidia donnani*, n. sp. Nat. size.
Figs. 2 and 3. With the test removed, from right and left sides.
Fig. 4. The dorsal tubercle. × 40.
,, 5. The branchial sac. × 40.
,, 6. The dorsal lamina. × 40.
,, 7. The muscles of the mantle. × 40.
,, 8. Another specimen (Chilaw), with test removed.
,, 9. Dorsal tubercle of the same. × 40.
Figs. 10 to 12. *Ascidia depressiuscula*, Heller, three specimens. Nat. size.
Fig. 13. With test removed.
,, 14. Another specimen.
,, 15. Branchial sac of same. × 40.
Figs. 16 and 17. Other parts of branchial sac. × 40.
Fig. 18. Dorsal lamina. × 40.
Figs. 19 and 20. Two dorsal tubercles. × 40.
Fig. 21. Tentacles. × 40.
Fig. 22. Alimentary canal, enlarged.
Figs. 23 and 24. *Microcosmus manaarensis*, n. sp.
Fig. 25. Same opened, to show hairs of test.
,, 26. Showing the test free inside sandy coat.
,, 27. Atrial aperture, from inside.
,, 28. Test removed.
,, 29. Part of a tentacle.
,, 30. Dorsal tubercle and peripharyngeal bands. × 40.
,, 31. Part of branchial sac. × 40.
,, 32. *Microcosmus longitubis*, n. sp. Nat. size.
,, 33. Same, test removed.
,, 34. Part of branchial sac. × 40.
,, 35. Dorsal tubercle. × 40.
,, 36. *Rhabdocynthia pallida*, Heller.
,, 37. Test removed.
,, 38. Dorsal tubercle.
,, 39. Atrial aperture, alimentary canal and left gonads, from inside, slightly enlarged.

PLATE III.

Figs. 1, 2, 3 and 4. *Rhabdocynthia ceylonica*, n. sp. Nat. size.

Figs. 5 and 6. Test removed from right and left sides.

Fig. 7. The branchial sac. × 40.

Figs. 8 and 9. Dorsal tubercles. × 40.

Fig. 10. Tentacles, face view. × 40.

„ 11. Tentacle, in profile. × 40.

Figs. 12, 13, 14 and 15. The echinated calcareous spicules.

Fig. 16. The dorsal tubercle and tentacles. × 40.

„ 17. The dorsal languets. × 40.

„ 18. White pigment flecks down the inside of each branchial lobe (alive).

„ 19. The same white pigmentation after preservation in formol.

„ 20. *Cynthia transversaria*, var. *manaarensis*, n. Nat. size.

Fig. 21. With test removed.

„ 22. Dorsal tubercle, languets, tentacles. × 40.

„ 23. The stigmata. × 40.

„ 24. Part of the branchial sac. × 40.

„ 25. *Cynthia crinitistellata*, Hrdn. Nat. size.

„ 26. One of the stellate hairs, enlarged.

„ 27. A group of hairs, enlarged.

Figs. 28 and 29. An echinated spine. × 40.

Figs. 30 and 31. *Cynthia aripuensis*, n. sp. Nat. size.

Fig. 32. Part of branchial sac. × 40.

„ 33. Lining of branchial siphon. × 40.

„ 34. Three of the spines enlarged. × 200.

„ 35. Test removed. Nat. size.

„ 36. The tentacles. × 40.

„ 37. The dorsal languets. × 40.

Figs. 38 and 39. Two dorsal tubercles. × 40.

PLATE IV.

Fig. 1. *Cynthia lanka*, n. sp., left side. Nat. size.

„ 2. Another, with a *Rhodosoma ceylonicum* (*Rh.*) adhering.

„ 3. Another, with a more marked ridge containing the apertures.

„ 4. Anterior end showing the ridge with the apertures.

„ 5. Test removed, left side.

„ 6. Test removed, right side.

Figs. 7, 8, and 9. The dorsal tubercle of different individuals. × 40.

Fig. 10. Three of the dorsal languets. × 40.

„ 11. Part of the branchial sac. × 40.

„ 12. The spicules lining the branchial siphon (× 40), two shown enlarged with the bases *in situ*.

„ 13. Part of the gonad, enlarged.

„ 14. *Molgula taprobane*, n. sp. Nat. size.

Figs. 15 and 16. The same from right and left sides, test removed. Nat. size.

Fig. 17. Part of the branchial sac and dorsal lamina. × 40.

„ 18. Specimen from Trincomalee. Nat. size.

„ 19. The dorsal tubercle. × 40.

Fig. 20. *Ctenicella ridgewayi*, n. sp., test removed, left side. × $2\frac{1}{2}$.

„ 21. The dorsal tubercle. × 40.

„ 22. The branchial siphon. × 10.

„ 23. Part of the branchial sac. × 40.

„ 24. *Styela areolata*, Heller. Nat. size.

„ 25. An unusually sandy specimen.

„ 26. A large specimen with a group of seven young pearl oysters adhering.

Figs. 27 to 30. The right and left sides of two specimens, with test removed, to show gonads.

„ 31 and 32. The dorsal tubercle of two specimens. × 40.

Fig. 33. Part of the branchial sac. × 40.

„ 34. *Polycarpa mutilans*, n. sp. Nat. size.

„ 35. The same cut open to show the interior with no branchial sac.

„ 36. Section of the body-wall to show the abundant endocarps. × 15.

„ 37. Dorsal lamina and branchial sac. × 40.

„ 38. Another specimen of this species.

„ 39. One of the large simple tentacles. × 40.

Figs. 40 to 42. Outlines of endocarps, enlarged.

„ 43 and 44. Dorsal tubercle of two specimens. × 40.

PLATE V.

Fig. 1. *Polycarpa aurata*, Q. and G. Nat. size.
,, 2. Section of the test, to show the pigment in the vessels. × 40.
,, 3. Part of the mantle, to show the pigment masses. × 40.
,, 4. Dorsal edge of prebranchial zone. × 5.
,, 5. Surface of dorsal tubercle. × 40.
,, 6. Part of branchial sac. × 40.
Figs. 7 to 9. *Styela lapidosa*, n. sp. Nat. size.
Fig. 10. Test removed, from left side. Nat. size.
,, 11. Another specimen with finer sand.
,, 12. The same, test removed, left side.
,, 13. Another specimen, right side.
,, 14. Part of branchial sac. × 40.
,, 15. The tentacles and dorsal tubercle. × 40.
,, 16. *Polycarpa sluiteri*, n. sp. Nat. size.
,, 17. Dorsal tubercle and tentacles. × 40.
Figs. 18 and 19. Dorsal tubercle of two other specimens. × 40.
Fig. 20. Gonads of left side. Nat. size.
,, 21. Part of branchial sac. × 40.
,, 22. Group of four *Polycarpa chalmersi*, n. sp., on a piece of coral. Nat. size.
,, 23. *Polycarpa chalmersi* adhering to *Ramulina* tubes. Nat. size.
,, 24. Part of branchial sac. × 40.
,, 25. Dorsal tubercle. × 40.
,, 26. One of the polycarps. × 40.
,, 27. *Styela ascidioides*, n. sp. Nat. size.
,, 28. Branchial aperture of same, enlarged.
,, 29. Test removed, left side. Nat. size.
,, 30. Section of test. × 40.
,, 31. Tentacles and dorsal tubercle. × 40.
,, 32. Part of branchial sac. × 40.
,, 33. *Polycarpa alentura*, n. sp. Nat. size.
,, 34. Alimentary canal. Nat. size.
,, 35. Two anterior dorsal languets. × 40.
,, 36. Dorsal tubercle, &c. × 40.
,, 37. Part of the branchial sac. × 40.

PLATE VI.

Fig. 1. *Polycarpa colletti*, n. sp. Nat. size.
,, 2. Tentacles and dorsal tubercle.
,, 3. Diagram of a branchial fold.
,, 4. Part of the branchial sac.
,, 5. *Polycarpa palkensis*, n. sp., removed from the sandy test. Nat. size.
,, 6. Dorsal tubercle. × 40.
,, 7. Part of branchial sac. × 40.
,, 8. One of the gonads. × 25.
,, 9. *Polycarpa willisi*, n. sp. A little enlarged.
,, 10. With test removed. Nat. size.
,, 11. Branchial aperture. Enlarged.
,, 12. Part of branchial sac. × 40.
,, 13. Tentacles and dorsal tubercle.
,, 14. Inside of body-wall, opened ventrally, to show the gonads. *p.*, polycarp; *end.*, endocarp.
,, 15. A pigmented endocarp.
,, 16. *Polycarpa manaarensis*, n. sp. Nat. size.
,, 17. Dissection to show wide prebranchial zone between tentacles and dorsal tubercle. Enlarged.
Figs. 18 and 19. Dorsal tubercle of two individuals.
Fig. 20. Tentacles.
,, 21. Dorsal lamina. × 40.
,, 22. Part of branchial sac. × 40.
,, 23. *Polycarpa* sp. (?). Nat. size.
,, 24. *Styela pigmentata*, n. sp. Nat. size.
,, 25. Part of branchial sac. × 40.
,, 26. Dorsal tubercle. × 40.
,, 27. *Polycarpa twynami*, n. sp. Nat. size.
,, 28. Rectum, showing fringed anus. Enlarged.
,, 29. Dorsal tubercle.
,, 30. Another specimen, right side. Nat. size.
,, 31. Part of branchial sac. × 40.
,, 32. Tentacles and dorsal tubercle. × 20.
,, 33. *Polycarpa decipiens*, n. sp. Nat. size.
,, 34. Diagram of one side of branchial sac, to show the folds (I.–IV.) and the number of stigmata in the meshes (14, 10, 8, &c.).
,, 35. Part of branchial sac. × 40.
,, 36. Dorsal tubercle. × 40.
,, 37. Alimentary canal and gonads. Enlarged.
,, 38. A polycarp, showing the ducts (*o.d.* and *v.d.*). × 30.
,, 39. Some of the spermatic cæca from a polycarp. × 40.

PLATE VII.

Fig. 1. *Gynandrocarpa imthurni*, n. sp., group of ascidiozooids.
,, 2. Part of the colony in profile.
,, 3. Part of a section to show the flattening of the ascidiozooids.
,, 4. Part of the branchial sac. × 40.
,, 5. The tentacles and dorsal tubercle. × 40.
,, 6. The dorsal tubercle more magnified.
,, 7. The atrial tentacles. × 40.
,, 8. The hermaphrodite gonad. × 40.
,, 9. The same in profile. × 40.
,, 10. *Diandrocarpa brakenhielmi*, var. *ceylonica*. Nat. size.
,, 11. A few ascidiozooids showing pigmentation and marginal vessels. × 20.
,, 12. Ascidiozooid removed from the test. × 25.
,, 13. The alimentary canal. × 40.
Fig. 14. The tentacles. × 40.
,, 15. The gonads of one side. × 40.
,, 16. Part of the branchial sac. × 40.
,, 17. Marginal vessels from the test. × 40.
,, 18. Branchial and atrial apertures, showing tentacles, &c. × 40.
,, 19. *Botryllus ater*, n. sp. Nat. size.
,, 20. The terminal knobs of vessels in the test. × 40.
,, 21. *Botrylloides cheralense*, n. sp. Nat. size.
,, 22. Four adjacent ascidiozooids. × 40.
,, 23. Part of branchial sac magnified more highly.
,, 24. Some of the branchial tentacles. × 100.
,, 25. *Botrylloides nigrum*, n. sp. Nat. size.
,, 26. *Colella arenosa*, n. sp., head. × 3.
Figs. 27 to 29. Parts of a colony. Nat. size.

PLATE VIII.

Fig. 1. *Hypurgon skeati*, Sollas, showing arrangement of ascidiozooids, enlarged.
,, 2. *Psammaplidium aurantiacum*, n. sp., section of test.
,, 3. Section of colony (nat. size), to show ascidiozooids.
,, 4. Surface to show ascidiozooids and sand, enlarged.
Figs. 5 and 6. Ascidiozooids. × 40.
Fig. 7. *Psammaplidium* sp. B, showing the red grains around the ascidiozooids.
,, 8. *Psammaplidium ceylonicum*, n. sp., an ascidiozooid. × 40.
,, 9. The terminal process of the post-abdomen, enlarged.
,, 10. Section of the colony. Nat. size.
,, 11. Surface of colony, a little enlarged.
,, 12. *Leptoclinum ramosum*, n. sp., section of colony, enlarged.
,, 13. Deeper section to show network of spicules. × 20.
,, 14. Single spicule. × 40.
,, 15. *Leptoclinum ceylonicum*, n. sp., section across a bar of the colony. Nat. size.
,, 16. Optical section of a passage through the colony. Nat. size.
Fig. 17. Surface showing common cloaca, &c., a little enlarged.
,, 18. Two spicules. × 40.
,, 19. *Leptoclinum margaritifera*, n. sp., horizontal section. × 40.
,, 20. Part of test. × 300.
,, 21. Testis and spiral vas deferens. × 300.
,, 22. One side of branchial sac. × 300.
,, 23. *Cystodytes ceylonensis*, n. sp., three colonies. Nat. size.
,, 24. Overlapping calcareous discs. × 40.
,, 25. One disc showing structure. × 50.
,, 26. *Didemnum areolatum*, n. sp. Nat. size.
,, 27. Section of colony, some spicules enlarged.
,, 28. *Leptoclinum viride*, n. sp. Nat. size.
,, 29. Section through upper surface. × 300.
,, 30. A deeper section. × 300.
,, 31. A spherical pigment cell, enlarged.
,, 32. One of the spicules. × 1000.
,, 33. Surface view of the colony. × 40.
,, 34. *Diplosoma viride*, n. sp., a large and a small colony. Nat. size.
,, 35. Section of test. × 300.
,, 36. Small colony, mounted whole. × 40.
,, 37. Thorax of ascidiozooid. × 300.

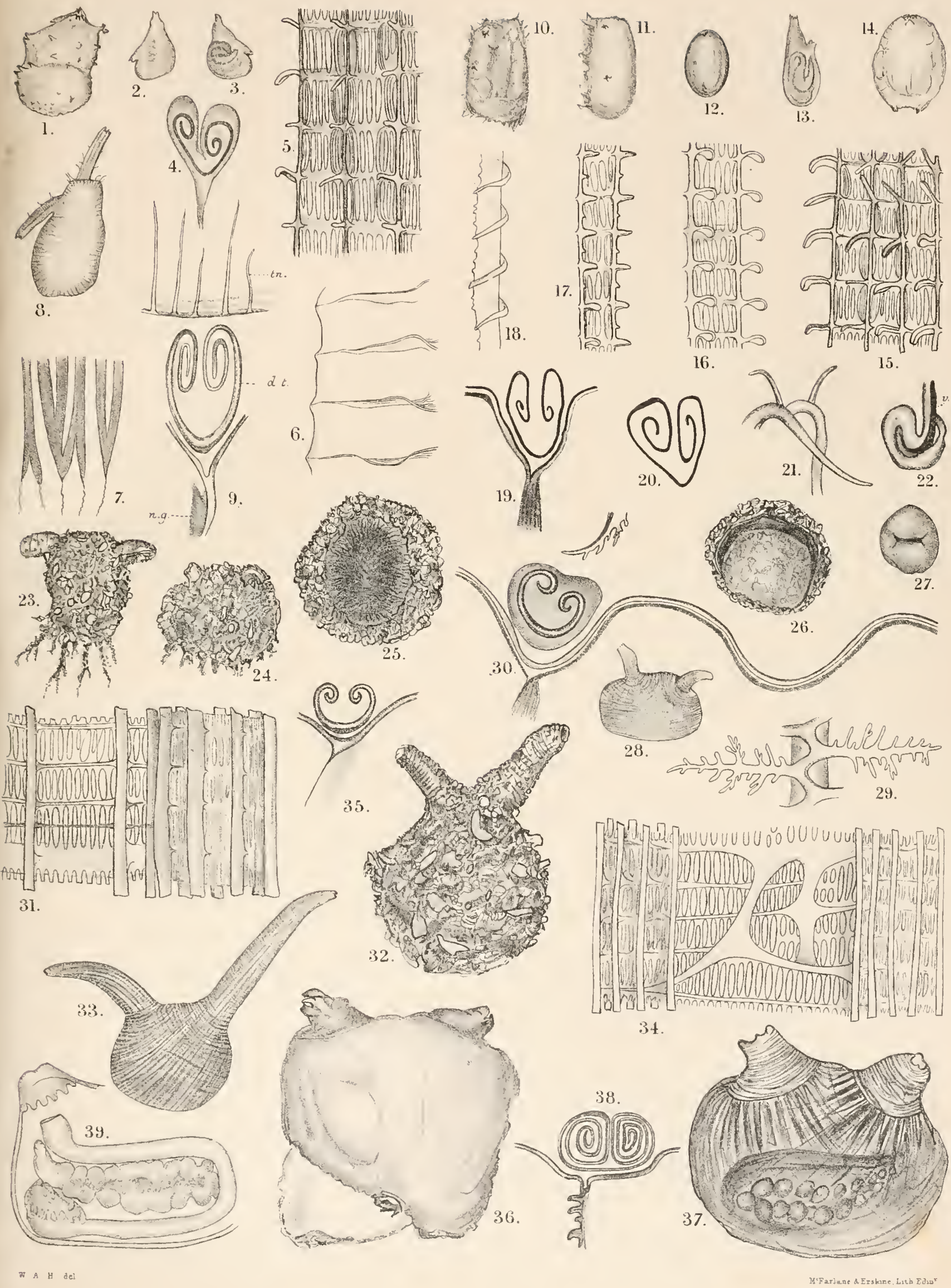
Fig. 38. One side of branchial sac. × 300.
,, 39. Ascidiozooid and advanced bud. × 300.
,, 40. Small colony, mounted whole. × 40.
,, 41. Echinated *Leptoclinum* sp. (?). Nat. size.
Fig. 42. Three spiny papillæ from the surface, in profile, enlarged.
,, 43. *Amaroucium* sp. (?). Nat. size
,, 44. *Diplosoma* sp. (?), two colonies. Nat. size.

PLATE IX.

(All the figures on this plate are reproduced from photographs.)

Fig. 1. *Leptoclinum ceylonicum*, n. sp., Palk Bay.
,, 2. Another colony from off Chilaw.
,, 3. *Leptoclinum ramosum*, n. sp.
,, 4. *Leptoclinum ceylonicum*, var. *planum*, below, with *Gynandrocarpa imthurni*, n. sp., above.
,, 5. *Hypurgon skeati*, Sollas.
Fig. 6. *Diplosoma viride*, n. sp.
,, 7. *Leptoclinum margaritiferæ*, n. sp.
,, 8. *Psammaplidium aurantiacum*, n. sp.
,, 9. *Psammaplidium ceylonicum*, n. sp.
,, 10. *Psammaplidium* sp. A.
,, 11. *Psammaplidium* sp. B.

W. A. H. del. McFarlane & Erskine, Lith. Edin.



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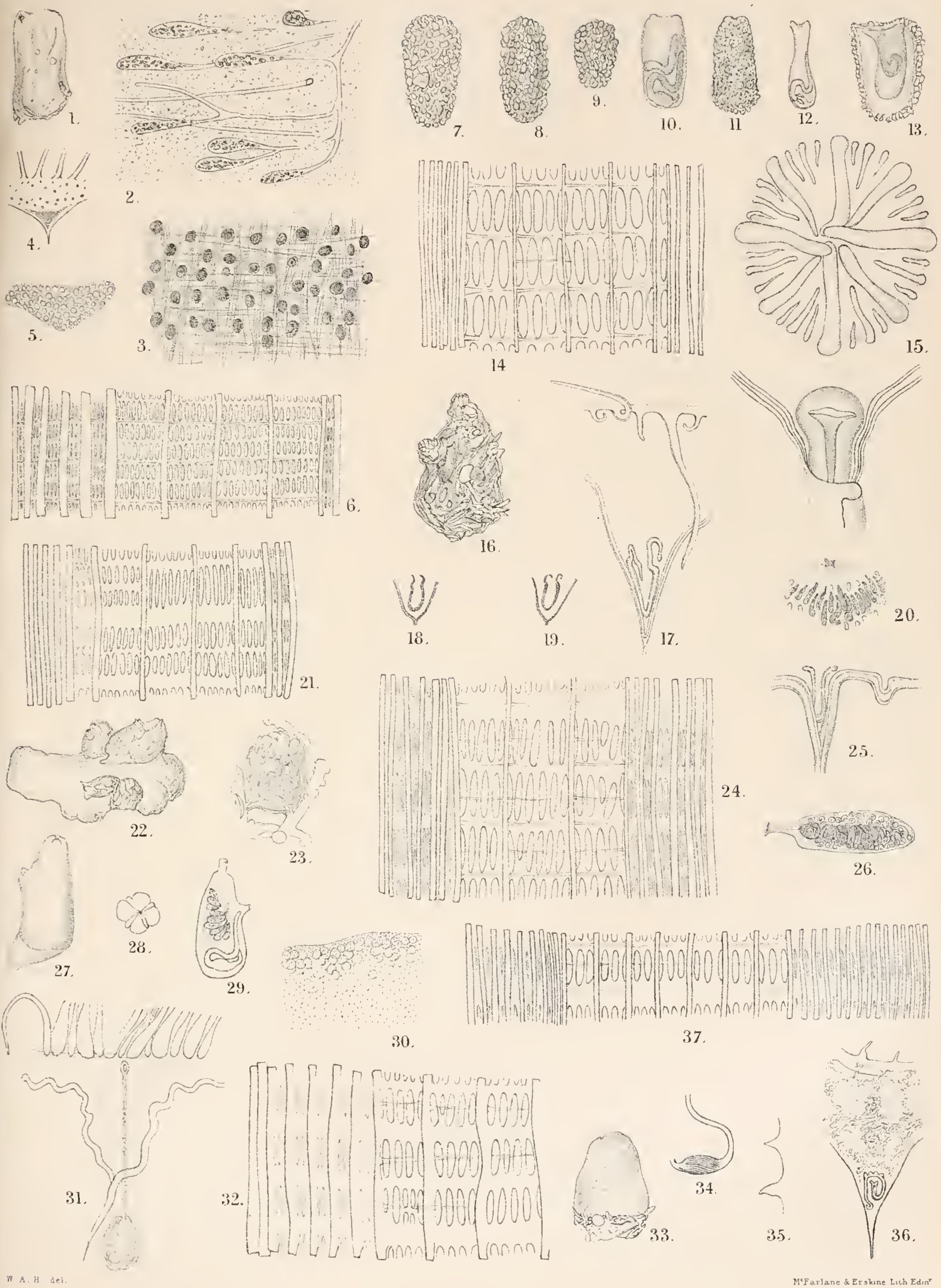

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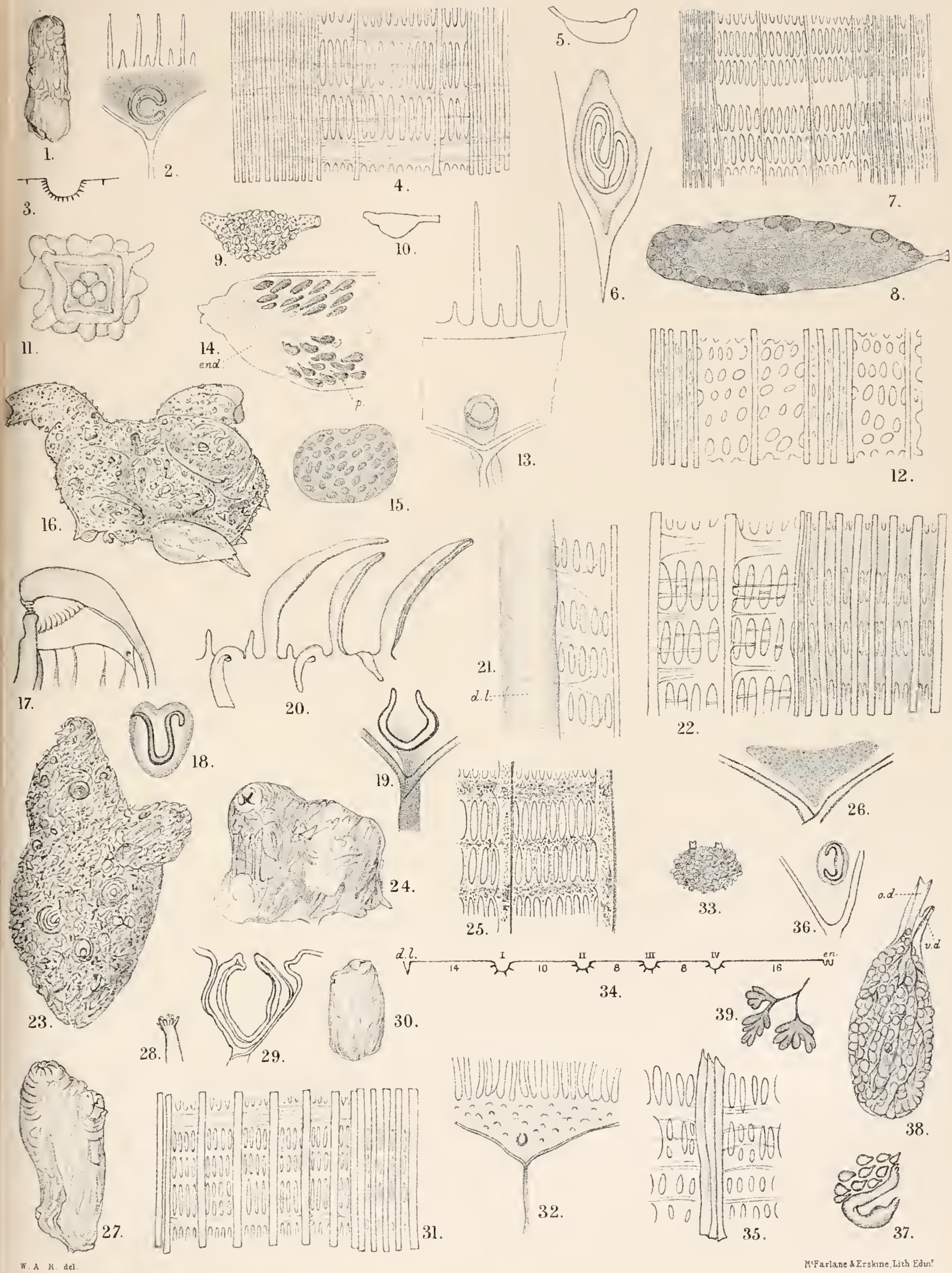

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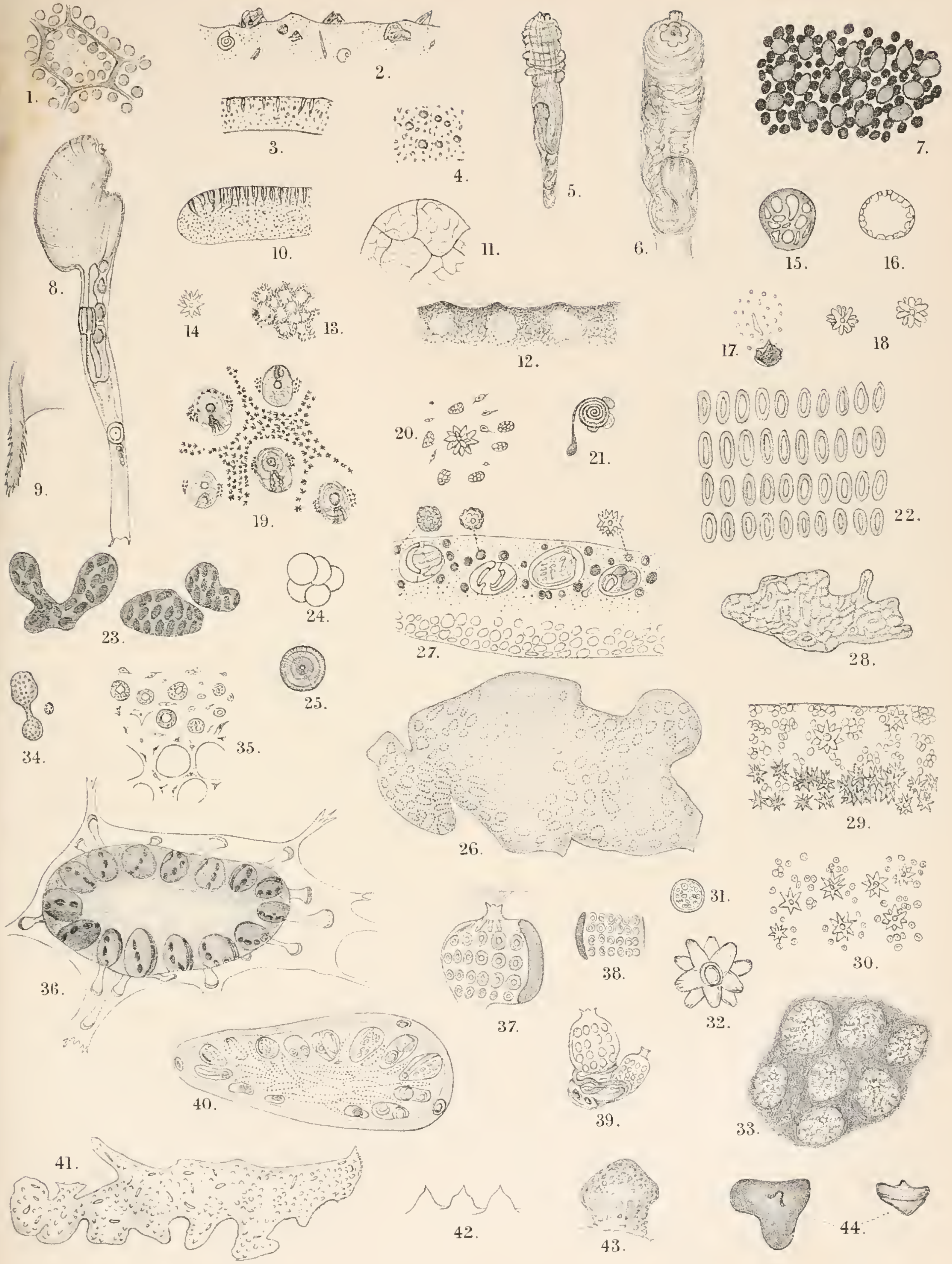

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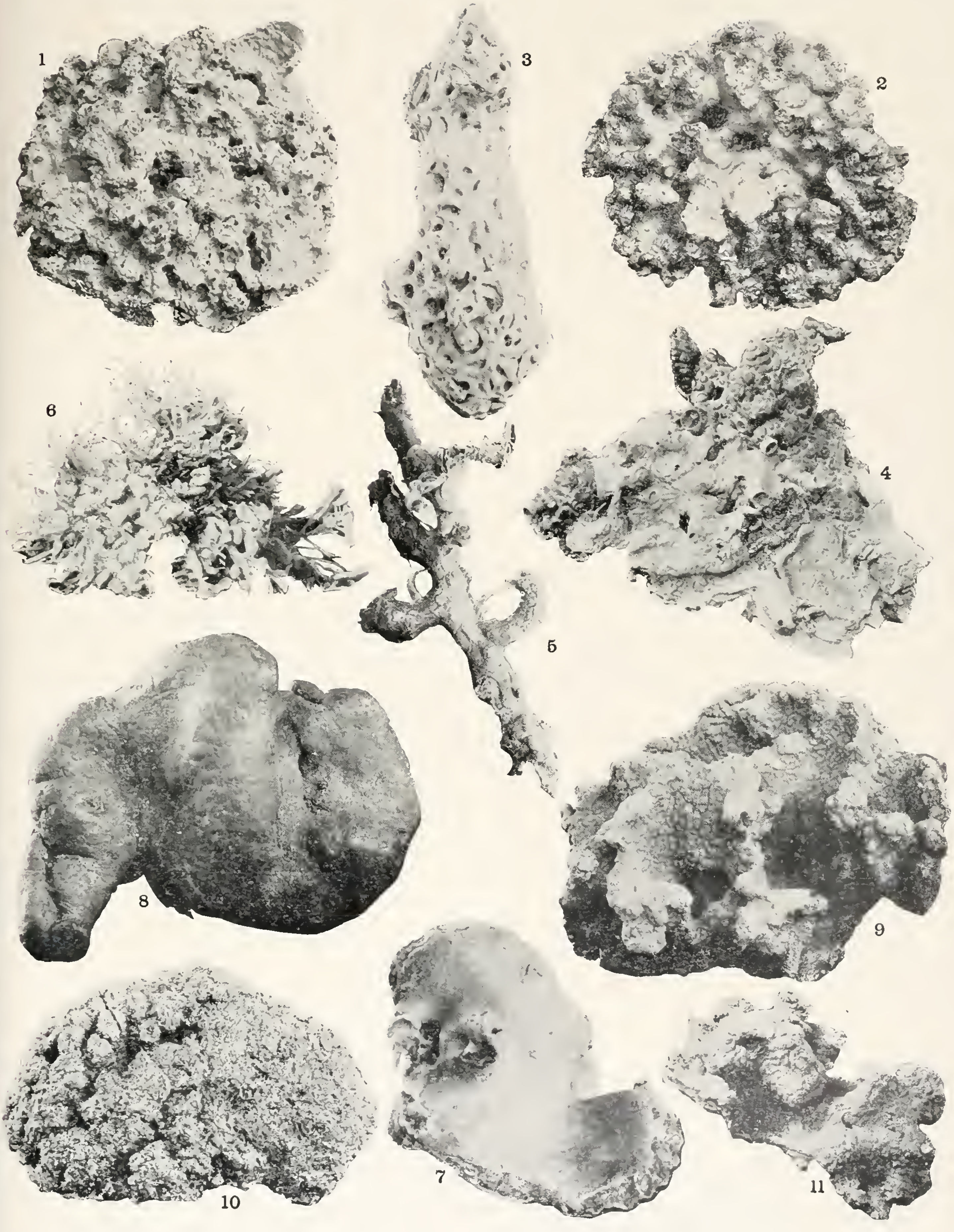

REPORT

ON THE

BRACHYURA

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

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[WITH TWO PLATES AND TEXT-FIGURES.]

INTRODUCTORY.

THE collection comprises 208 species, of which 15 are described as new, and of the latter, three are referred to new genera. Of the three new genera, two are Xanthids (one a large crab which I place near to *Zozymus*—the other a curious little animal with a *Kraussia*-like carapace and a most remarkable hand); the third belongs to the interesting group of Rhizopinæ.

The new species belong to the following genera :—*Dromia* (1), *Tlos* (1), *Achæus* (1), *Halimus* (2), *Cryptopodia* (1), *Doclea* (1), *Actæa* (1), *Euxanthus* (1), *Neptunus* (2), *Pinnoteres* (1), and the three new genera, *Demania* (1), *Mertonia* (1), and *Calmania* (1).

Descriptions of some little known forms have been revised in the light of examples contained in the collection. Among these may be mentioned *Philyra adamsi*, about which there has been misunderstanding. Many of the species and even some of the genera in the collection are new to the India fauna, and the majority had not previously been recorded from the coast of Ceylon.

A matter of considerable interest—both general and systematic—is well illustrated among the Oxyrhyncha collected. I refer to the phenomenon which GEOFFREY SMITH has recently* investigated very thoroughly in *Inachus scorpio* (= *dorsettensis*)

* 'Mittheil. Zool. Stn. Neapel,' xvii., p. 312; see also H. A. HAGEN, "N. Amer. Astacidæ," in 'Ill. Cat. Mus. Comp. Zool. Harvard,' 1870; W. FAXON (1) 'Amer. Journ. Sci.,' xxviii., p. 42, and (2) 'Revision of the Astacidæ,' part i., 1885.

and termed by him facultative dimorphism. SMITH has shown that in males of this species there are at least two breeding periods ("low" and "high" respectively) characterised by well-developed secondary sexual characters, and that between these is intercalated a non-breeding phase ("middle") in which the secondary sexual characters are not evident. What SMITH has concluded for *Inachus scorpio* from statistical evidence, WALTER FAXON had found in a *Cambarus* reared by him in an aquarium. HAGEN had previously described two types of male *Cambarus* and considered them to be characteristic of different individuals, but FAXON, observing aquarium-kept animals, found that the two conditions detailed by HAGEN were alternate phases in the life-history of the same individual correlated with the breeding and non-breeding period respectively; the breeding male with pronounced secondary sexual characters changed by a moult to the non-breeding form with much resemblance to the young. A very beautiful example of facultative dimorphism is added to the above by a series of *Menœthius monoceros* in the present collection. There is evidence that the same kind of thing is of wide occurrence amongst the Oxyrhynchs.

The importance of the matter for systematic zoology may be emphasised by reference to *Simocarcinus simplex* and *S. pyramidatus*, one of the very few differentia between which is the cheliped character—a difference for which the theory of facultative dimorphism offers an alternative explanation.

In working over a large collection of crabs, attention is constantly attracted by the considerable amount of growth and of correlation-change which commonly occurs after sexual maturity.

Certain contractions have been found convenient in the following pages:—

C. = carapace. Ch. = cheliped, W.L. = walking leg, F. = finger (dactylus of cheliped), H. = hand, l. = length, b. = breadth, Bord. = border, R. = rostrum. Unless otherwise stated, Ch.l. is measured along the morphological ventral border, and is the sum of (1) a straight line uniting the base of the appendage to the distal end of the merus, and (2) a straight line uniting the last-named point to the tip of the fixed finger. In Oxystomata it is measured along middle of posterior surface.

Measurements are in all cases given in millimetres.

Colonel ALCOCK'S "Materials for a Carcinological Fauna of India" is indispensable to the student of Indian crabs. I have followed him where possible in matters of nomenclature and classification.

Space forbids synonymies; I have in most cases made reference to one good account only of the species in question. A useful list of the literature will be found in KLUNZINGER (1906). The following contractions have been employed:—

A.1.–A.6. = ALCOCK, "Materials, &c.," No. 1–No. 6, in 'Journ. Asiat. Soc. Bengal, 1895 to 1900.

A.Cat. = ALCOCK, 'Cat. Ind. Decap. Crust. Ind. Mus.' Part I. Brachyura. Fasc. 1. Dromiacea, 1901.

A.Invest. = ALCOCK, "Crust." in 'Illusts. Zool. "Investigator."'

B.I.–B.XIII. = BORRADAILE'S Crust. in GARDINER'S 'Fauna, &c., Mald. and Lacc.'

N. = NOBILI, 'Bull. Sci. France et Belg.,' vol. xl., 1906.

K. = KLUNZINGER, 'Spitz- u. Spitzmund-Krabben d. Rothen Meeres.' Stuttgart, 1906.

C. = CALMAN, 'Trans. Linn. Soc.,' ser. 2, Zool., vol. viii., 1900.

H. = HENDERSON, 'Trans. Linn. Soc.,' ser. 2, Zool., vol. v., 1893.

R. = RATHBUN, 'Bull. U.S. Fish. Comm. for 1903.'

My thanks are due in the first instance to Professor HERDMAN for entrusting to my examination this large and interesting collection. Much of the work has been done at the British Museum, and my indebtedness is great to Dr. CALMAN for the courtesy and kindness with which he has facilitated my work among the collections under his charge. Finally, I thank Miss WOODWARD for her excellent drawings and Mr. H. HERRING and Mr. W. J. DAKIN for valuable photographic aid.

DESCRIPTION OF THE SPECIES.

DROMIACEA.

Dromia intermedia, n. sp.

Locality :—Deep water off Galle, one specimen.

Description :—Female, non-ovigerous, but quite possibly mature.

C.l. 23·50, including frontal teeth.

$C.b._1$ 23·50, straight line uniting tips of last pair of antero-lateral teeth.

$C.b._2$ 23·00, straight line uniting tips of teeth immediately behind cervical groove.

W.L.2.l. 27·25, sum of dorsal borders of (1) meropodite and (2) the three distal segments together (9·0+18·25). W.L.3.l. 14·00 (5·5+8·5). W.L.4.l. 16·00 (7·0+9·0).

It agrees with ALCOCK'S description (A.5, p. 138; A.Cat., pl. ii., fig. 5) of *Dromia cranioides*, DE MAN, except in two very obvious particulars, in which it resembles *Dromia rumphi*, FABRICIUS, 1798 (A.5, p. 137; A.Cat., pl. ii., fig. 4), namely :—(1) Walking leg 4 but little longer than walking leg 3; (2) the sternal grooves of the female terminate on very prominent tubercles set well apart on anterior portion of segment of walking leg 1. A third difference from *D. cranioides* is that the spine on the distal end of the "posterior" border of the propodite of walking leg 4 is slender and only about ½ length of "anterior" spine (*i.e.*, the one opposing the dactylopodite). There are on the same segment various smaller spinules.

Dromidia unidentata (RÜPPELL), 1830—A.5, p. 139; A.Cat., pl. ii., fig. 6.

Locality :—West of Periya Paar, Station LXIII., 17 to 24 fathoms, one specimen.

Description : Ovigerous female, C.l. = 11·00; C.b. ÷ C.l. = 1·00.

The present example is about half the size of those recorded by ALCOCK, DE MAN, and HENDERSON.

Dromidiopsis australiensis (HASWELL), 1882—A.Cat., p. 76.

Localities:—Chilaw Paar, Station LXIX., 8 to 11 fathoms, one specimen (*a*); Jokkenpiddi Paar, 10 fathoms, one specimen (*b*).

Description:—(*a*) Ovigerous female, agrees fairly well with ALCOCK'S description, C.l. = 16·50; C.b. ÷ C.l. = 0·97. (*b*) This is BORRADAILE'S var. *bidens*, 1903 (B.IX., p. 576), C.l. = 9·25; C.b. ÷ C.l. = 0·97.

Cryptodromia canaliculata, STIMPS., 1858—A.5, p. 142; A.Cat., pl. ii., fig. 8.

Locality:—Galle, one specimen.

Description:—Young male, C.l. = 4·25; C.b. ÷ C.l. = 1·12.

In this young specimen the second of the two teeth on the antero-lateral border of the carapace is represented by a bluntly angular lobe.

Cryptodromia bullifera, ALCOCK, 1899—A.5, p. 143; A.Cat., pl. ii., fig. 9.

Locality:—Cheval Paar, one specimen.

Description:—Young female, C.l. = 5·50; C.b. ÷ C.l. = 1·00.

Cryptodromia demani, ALCOCK, 1899—A.5, p. 144.

Locality:—Station LIV., 10 fathoms, south of Manaar Island, two specimens.

Description:—

	(*a*) ovigerous female.	(*b*) ad. non-ov. female.
C.l.	5·40	5·50
C.b. ÷ C.l.	1·02	1·04

I believe the present forms may be placed under the above species, which has not been hitherto figured. The characteristic dorsal hepatic tooth is weak in (*a*), a little more strongly developed in (*b*). The dactylopodite of walking leg 4 is apposed by a quite fairly developed spine of the propodite; the propodite of walking leg 3 bears a similar but smaller spine. A transverse groove runs behind the front and orbits. The sternal grooves end apart, without very obvious tubercles, just behind the segment bearing the chelipeds.

Cryptodromia hilgendorfi, DE MAN, 1887—A.5, p. 145; A.Cat., pl. iii., fig. 11.

Locality:—Mutwal Island, Station LXVI., 30 fathoms, one specimen.

Description:—Ovigerous female, C.l. = 14·50; C.b. ÷ C.l. = 1·03.

There is a slight indication of a second tooth on the antero-lateral border of the carapace, behind the tooth at the antero-lateral angle.

Remarks:—BORRADAILE has in his suggestive revision of the Dromiacea ('Ann. Nat. Hist.,' ser. 7, vol. xi., p. 299, 1903) included the present species in a new genus, *Dromides*. NOBILI (p. 93) criticises this genus

Cryptodromia gilesi, ALCOCK, 1899—A.5, p. 146; A.Cat., pl. iii., fig. 13.

Locality:—Gulf of Manaar, one specimen.

Description:—Male, C.l. = 8·25; C.b. ÷ C.l. = 1·03 (C.b. = straight line uniting tips of last antero-lateral teeth).

Conchœcetes artificiosus (FABR.), 1798—A.5, p. 151; A.Cat., pl. iii., fig. 16.

Locality:—Trincomalee, three young specimens (*a*, *b*, *c*).

Description:—

	(*a*)	(*b*)	(*c*)
C.l.	7·00	7·00	7·25
C.b. ÷ Cl.	—	0·96	0·96

Remarks:—New to the Ceylon fauna.

Conchœcetes andamanicus, ALCOCK, 1899—A.5, p. 152; A.Cat., pl. iii., fig. 17.

Locality:—Pearl banks, Gulf of Manaar, one specimen.

Description:—Male, probably adult. C.l. (frontal teeth included) = 10·25; C.b. ÷ C.l. = 1·00.

It confirms ALCOCK'S doubtfully created species, showing, however, certain additional points of difference from *C. artificiosus* not mentioned by ALCOCK:—(1) Prominent fringe of longish hairs on antero-lateral borders of carapace; (2) well-marked median longitudinal groove on anterior part of the carapace running back from notch between the frontal teeth (its length ÷ C.l. = 0·19); (3) the well-developed pair of frontal teeth more strongly deflexed; (4) sub-hepatic regions by no means so swollen, in correlation with which one finds that the antero-lateral border of the buccal cavern slopes downwards from the straight anterior border of the same region at a more obtuse angle (80° approximately instead of 65° approximately); (5) a kind of elongated tubercle occupies middle region of a not very well-marked ridge connecting lateral termination of cervical groove and antero-lateral angle of buccal cavern.

The specimen is protected by a *Pectunculus* valve.

OXYSTOMATA.

Calappa lophos (HERBST), 1785—A.2, p. 144.

Localities:—Trincomalee, one specimen (*a*); Gulf of Manaar, one specimen (*b*).

Description:—

	(*a*) young female.	(*b*) young male.
C.l.	8·50	14·75
C.b. ÷ C.l.	1·26	1·36

Remarks.—Recorded as fossil by DE MAN from post-tertiary of Celebes ('Samm. Geol. Mus. Leiden,' (1), vii., p. 277, 1904).

Calappa philargius (LINNÆUS), 1764—A.2, p. 145.

Localities:—Gulf of Manaar, one specimen (*a*); Station I., off Negombo, one

fringe on under surface of meropodite of walking leg 4. In (B) hair is absent in these regions.

Post-cardiac transverse groove slight but distinct in (A); absent in (B).

Third tooth of clypeiform expansion.—(A) Less acute than in (B); points obliquely forward; has anterior border ÷ posterior border = 0·54 (average of eight specimens).

(B) Acute; points laterally; has anterior border ÷ posterior border = 0·90 (average of nine specimens).

I do not suggest that the above distinctions would be absolute or their correlation perfect for a large series. This would be to separate series (B) as a species apart from *C. gallus.*

In the British Museum is a specimen (adult female, Philippine Islands, 43.6) which combines the (A)-type of front with the (B)-type of the other characters. Another unites the deep hepatic concavity of (A)-type with a more (B)-like front. BRITTO CAPELLO'S figure suggests that his specimen had rougher, more prominent tubercles than (B).

One of present series (B) has a line of hairs posteriorly as in (A) and traces of the same occur in three others.

It is best, I think, for the present, to consider the two groups as varieties which one may call :—(A), var. *gallus*, and (B), var. *capellonis.*

The best distinction between them is perhaps the shape and direction of the 3rd tooth of the clypeiform expansion, which may be expressed by index anterior border ÷ posterior border. Examination of this character in our series shows :—

Var. *gallus* . .	Mean = 0·54 ;	range of variation = 0·50–0·55 (8 examples).
,, *capellonis* .	,, = 0·90 ;	,, ,, = 0·83–1·07 (9 ,,).

Growth changes do not affect correlation much in these specimens :—

In var. *gallus*, 10 specimens considered (6 young + 4 adult).

	6 females (1 adult).	4 males (3 adult).
C.l.	9·00–31·50	10·25–33·25
$C.b._1 \div C.l.$.	0·95– 0·98	0·95– 0·96
$C.b._2 \div C.l.$.	0·81– 0·86	0·78– 0·85 (Index decreases with size).

Var. *capellonis*, 19 specimens (1 adult male).

	10 females.	9 males.
C.l.	7·25–25·75	8–33·25
$C.b._1 \div C.l.$ ..	0·98– 1·00	0·95–1
$C.b._2 \div C.l.$.	0·79– 0·88	0·74–0·90 (Index decreases with size).

($C.b._1$ = in front of clypeiform expansions. $C.b._2$ = across 3rd tooth of clypeiform expansions.)

Mursia bicristimana, ALCOCK & AND., 1894—A.2, p. 150; A.Invest., pl. xxiv., fig. 5.

Locality :—Gulf of Manaar and Palk Straits, two specimens.

Tlos havelocki, n. sp.—Plate I., fig. 2, and text-fig. 1.

Locality :—Coral reefs, Gulf of Manaar, one specimen.

Description :—An adult male. C.l. = 5·75 ; C.b. ÷ C.l. = 1·48 ; Ch.l. ÷ C.l. = 1·09 ; arm l. (inner border of under surface) ÷ C.l. = 0·48 ; propus l. (lower border) ÷ C.l. = 0·61 ; F.l. ÷ H.l. (upper border) = 1·14. (Ch.l. is the sum of arm l. and propus l.)

Carapace broadly pentagonal—the front produced and strongly upturned and having its anterior border flattened and a little emarginate in the middle line—the antero-lateral and postero-lateral angles of the pentagon are rounded—the anterior sides concave—the lateral sides converge posteriorly a little—the posterior side is divided by two deep notches into three lobes which all project backwards to approximately the same level. The branchio-hepatic regions are concave and the post-cardiac region deeply so. There are two marginal sutures on each side—one supra-orbital, the other about midway between this and the antero-lateral angle. The margins of the carapace are a little thickened, a little upturned and bordered by enlarged granules as far forward as the more posterior pair of sutures—between the latter and the supra-orbital pair they are rounded and less distinctly granulated—the frontal margin is merely roughened. The true posterior border of the carapace and the surface rising vertically above it are covered with enlarged granules. A longitudinal ridge runs backward from the front to the cardiac region. The latter is prominent and is crowned by a transverse ridge uniting the anterior ends of a pair of very strongly developed, broad topped, granular ridges which run obliquely backward to be continued into the lateral margins at the postero-lateral angles of the pentagon. The rest of the dorsum of the carapace is smooth to the naked eye (seen under lens to be uniformly covered by obsolescent granules).

Fig. 1. *Tlos havelocki*, n. sp.

The pterygostomian region is prominent, its summit is forwardly directed and surmounted by a couple of granules. The exposed portions of the thoracic sterna are covered with enlarged granules—the rest of the under surface of the body, *i.e.*, pterygostomian, sub-hepatic, and sub-branchial regions, is smooth to the naked eye (obsolescently granular under lens).

The orbits are largely ventral. The eyes are visible in part only, in a dorsal view.

Antennules not remarkable.

External maxillipedes with exposed surface roughened ; not remarkable in form.

Chelipeds—Ch.l. ÷ C.l. = 1·48. The distal end of the arm is seen beyond the carapace (arm l. ÷ C.l. = 0·47). The arm is trigonal, with enlarged granules along its borders—its surfaces are smooth to naked eye (obsolescently granular under lens). Wrist rounded—its borders and much of its surfaces granular. Hand with outer and inner borders granular—under surface rounded and bearing granules which tend to run in rows, of which one curves downwards and outwards from the inner side of the proximal end to be continued along the whole under surface of the propus to the tip

of the fixed finger. The horizontal upper surface of the hand meets the oblique antero-inner surface at an angle, forming an oblique ridge crowned by a characteristic row of enlarged granules (six in this specimen). The inner surfaces of hand and fingers form together a hollowed area. The fixed finger is not constricted off from the hand and is much more massive than the dactylus. The upper surface of the dactylus is fluted—three granular ridges defining two grooves. There are two longitudinal rows of granules on the fixed finger. The distal two-thirds of the apposed border of either finger is flattened to form a facet which is bordered by a few very sharp denticles; the tip of each finger forms a curved tooth—that of the dactylus closes to the inner side of that of the fixed finger.

The meropodites of walking legs 2, 3, and 4 are concealed by the carapace; the succeeding three segments are short, so that by folding the legs at the joint between meropodite and carpopodite they may be entirely concealed from dorsal view. [The first walking legs are lost.] The basipodites and the three distal segments are granular. The meropodites are trigonal, their borders tend to be granular, and their surfaces smooth (obsolescently granular under lens)—the proximal one-third of the under surface occupies a different plane from the distal two-thirds, and is granular.

Remarks.—The new species is closely related to *Tlos petræus*, A. Milne-Edwards, 1874 (A.2, p. 176), but may be easily distinguished from it by the unbroken character of the oblique post-cardiac ridges. It differs further from *T. petræus* in the following particulars:—(1) The front is more produced and more upturned; (2) the true posterior border of the carapace does not project further backward than the lobe on either side of it; (3) there are two marginal sutures only on each side; (4) there is a stronger contrast between the obsolescent granules of the general surface and the enlarged granules of special areas; (5) in the prominence of the pterygostomian region; (6) the orbits are less ventral; (7) sculpture of cheliped—in particular the presence of the oblique row of granules on the upper surface of the hand; (8) the facets on the apposed borders of the fingers.

Tlos latus, Borradaile, 1903 (B.VI., p. 437), differs in—(1) Absence of marginal sutures of carapace; (2) absence of oblique line of granules on upper surface of hand; and (3) isolation of lateral cardiac hump.

Lithadia sculpta, Haswell, var. **aglypha,** nov.—Text-fig. 2.

Locality:—Coral reefs, Gulf of Manaar, one specimen.

Description:—An immature individual. C.l. = 8·5.

It bears a considerable general resemblance to the already described form of *L. sculpta*, but differs from it in the following particulars:—(1) The carapace is broader in proportion to its length—C.b. ÷ C.l. = 1·26; (2) the two grooves which border the cardiac region laterally are not continued forward until they meet, but terminate apart in the middle region of the carapace; (3) there is a mere trace of an intestino-cardiac groove, quite different from the well-cut channels which the other

grooves present; (4) the granules on the arm and hand are not so sharp; (5) the strip of carapace cut off laterally by the skirting channel is narrower; between the slightly broadened portions which lie above the bases of cheliped and walking legs 1 and 3 it forms a quite thin ledge; (6) the sub-hepatic region is swollen, much as in *L. sculptus*, and the small tubercle at point of union of antero-lateral and postero-lateral borders is not double.

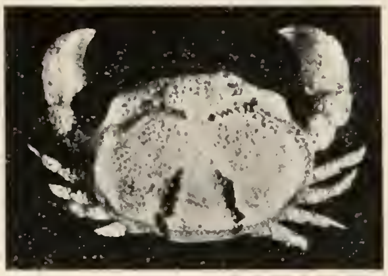


Fig. 2. *Lithadia sculpta*, var. *aglypha*, nov.

Remarks.—The single specimen is immature, but its order of size is much the same as that of a British Museum specimen of *L. sculpta*. This species is of rare occurrence. Only two other examples are known to me, from two localities (Arafura Sea and Eastern seas), but closely resembling each other, suggesting that variability may be low. The present form may turn out to be the representative of a new species.

Nursia plicata (Herbst), 1804, nec auctorum—A.2, p. 180.

Localities:—Adam's Bridge, one specimen (*a*); pearl banks, Gulf of Manaar, one specimen (*b*).

Description:—	C.l.	C.b. ÷ C.l.	Ch.l. ÷ C.l.	F.l. ÷ H.l.
(*a*) adult ♂ . .	10·25	1·27	1·63	0·55
(*b*) adult ♂ . .	12·50	1·20	1·72	0·54

In carapace length the posterior point is the indentation between the two posterior lobes. Carapace breadth measured by straight line uniting indentations between 2nd and 3rd lateral teeth of either side. In both specimens the greatest carapace breadth is given by a straight line uniting tips of 2nd lateral teeth of carapace—not 3rd pair as in *N. hardwicki*.

Nursia hardwicki, Leach, 1817—A.2, p. 181.

Localities:—Pearl banks, Gulf of Manaar, one specimen (*a*); Aripu Reef, one specimen (*b*); coral reefs, Gulf of Manaar, one specimen (*c*).

Description (C.l. and C.b. measured as in *N. plicata*):—

	C.l.	C.b. ÷ C.l.	Ch.l. ÷ C.l.	F.l. ÷ H.l.
(*a*) ♀ . . .	10·25	1·15	1·51	0·61
(*b*) ♀ . . .	10·75	1·12	1·49	0·56
(*c*) ♀ . . .	11·00	1·11	1·50	0·55

The most anterior of the four antero-lateral teeth, just behind the marginal nodule, is quite conspicuous in (*a*), but only slightly developed in the other examples. In all the greatest carapace breadth is given by a straight line uniting tips of 3rd lateral teeth—not 2nd as in *N. plicata*.

Ebalia diadumena, ALCOCK, 1896—A.2, p. 187.

Locality :—Galle, two specimens.

Description :—	(*a*) young ♀.	(*b*) ♂.			
C.l.	4·75	6·50	Ch.l. ÷ C.l. . . .	(*a*) 1·37	(*b*) 2·00
C.b. ÷ C.l. . .	1·05	0·96	F.l. ÷ H.l. . . .	0·83	0·77
			H.b. ÷ H.l. . . .	0·83	0·69

This is first record of male. It differs from ALCOCK'S female (Palk Straits) in a few respects :—(1) the gastro-cardiac groove is hardly to be distinguished ; (2) the cheliped granulation is not so extensive ; (3) about middle of striation on upper surface of immobile finger is a prominent elongated laterally compressed granule ; (4) abdominal tergum VI. is armed with strong terminal tooth.

Ebalia maldivensis, BORRADAILE, 1903—B.VI., p. 437, fig. 116.

Locality :—Gulf of Manaar, one specimen.

Description :—Ovigerous female, C.l. = 5·75 ; C.b. ÷ C.l. = 1·13 ; Ch.l. ÷ C.l. = 1·22 ; F.l. ÷ H.l. = 0·75. The mounds on dorsum of carapace are all distinct.

Myra* fugax (FABRICIUS), 1798—A.2, p. 202.

Locality :—Aripu coral reefs, Gulf of Manaar, three specimens (*b*, *d*, *f*) ; Trincomalee, five specimens (*a*, *c*, *e*, *g*, *h*) ; Galle, three specimens (*j*, *k*, *l*) ; off Manaar Island, one specimen (*i*).

Description :—*a–h*, young.						ovig.	ad.				ad.	ad.
	b (♀).	*d* (♀).	*e* (♀).	*f* (♀).	*h* (♀).	*i* (♀).	*l* (♀).	*a* (♂).	*c* (♂).	*g* (♂).	*j* (♂).	*k* (♂).
C.l.	9·00	12·00	12·25	12·50	17·00	18·00	26·00	8·75	11·50	16·50	19·00	24·75
C.b. ÷ C.l. .	0·86	0·87	0·88	0·86	0·88	0·86	0·85	0·89	0·87	0·82	0·87	0·86
Ch.l. ÷ C.l. .	1·69	1·79	1·79	1·76	1·98	1·86	2·12	1·83	1·85	1·95	2·33	2·38
H.l. ÷ C.l. .	0·39	0·44	0·47	0·42	0·51	0·47	0·58	0·46	0·46	0·51	0·62	0·65
F.l. ÷ H.l. .	0·93	0·86	0·78	0·90	0·80	0·79	0·77	0·81	0·86	0·68	0·74	0·72
H.l. ÷ H.b. .	2·29	2·50	2·87	2·50	2·69	2·67	3·16	2·09	2·62	2·83	3·36	3·56

Ch.l. is the sum of lengths of its segments, measured along median line of posterior surface. C.l. is without the spine.

Among the adult specimens considered to be mature, the sexual dimorphism in regard to cheliped length is by no means so marked as ALCOCK records.

In one specimen the more acutely bidentate and upturned front is somewhat reminiscent of *M. brevimana*. It has also a well-marked median longitudinal carina.

Specimen (*i*), an ovigerous female, is an interesting form which deserves note. It tends to combine characters of *M. fugax*, *M. affinis*, and *M. brevimana*. In slender build of chelipeds and in index F.l. ÷ H.l. it resembles *M. fugax*. In indices Ch.l. ÷ C.l. and H.l. ÷ C.l. it more nearly approaches *M. affinis* and *M. brevimana*. The prominence

* Miss RATHBUN unites this genus with the older genus *Persephona*, LEACH, 1817.

of the upper hepatic tooth is much as in *M. affinis*; the *Leucosia*-like front approximates to that of *M. brevimana*. The specimen is conveniently put under *M. fugax*.

Specimens (*d*) and (*f*) are young forms which may perhaps be put with specimen (*i*).

Myra affinis, Bell, 1855—A.2, p. 205.

Locality:—Pearl banks, Gulf of Manaar, five specimens (*g, h, i, j, l*); Coral reefs, Gulf of Manaar, four specimens (*a, d, f, k*); Trincomalee, three specimens (*b, c, e*); off Mutwal Island, one speimen (*m*).

Description:—

	a–k, young.								ad.			ad.
	a (♀).	*c* (♀).	*d* (♀).	*f* (♀).	*h* (♀).	*i* (♀).	*j* (♀).	*k* (♀).	*l* (♀).	*b* (♂).	*g* (♂).	*m* (♂).
C.l. (spine).	7·50	11·25	11·50	12·50	16·50	18·75	19·00	19·75	24·00	8·00	15·75	26·75
C.b. ÷ C.l.	0·93	0·89	0·87	0·88	0·84	0·88	0·86	0·86	0·87	0·91	0·86	0·86
Ch.l. ÷ C.l.	1·50	1·49	1·46	1·50	1·51	1·56	1·53	1·57	1·74	1·53	1·54	1·91
H.l. ÷ C.l.	0·40	0·40	0·39	0·40	0·42	0·44	0·42	0·43	0·49	0·41	0·45	0·56
F.l. ÷ H.l.	0·67	0·67	0·67	0·65	0·61	0·61	0·62	0·65	0·60	0·69	0·57	0·53
H.l. ÷ H.b.	2·00	2·00	2·00	2·00	2·15	2·20	2·13	2·12	2·14	2·17	2·34	2·50

Among the small specimens there is a marked tendency to possession of an additional postero-lateral pair of small spicules, a carina, an intestinal granule, and several enlarged antero-lateral denticles. A similar tendency is found in the small young placed under *M. fugax* and *M. brevimana*.

Specimen (*m*) male is large. Its C.l. is only 0·25 millim. less than that of Nobili's (p. 95) large specimen, but it by no means approaches the latter in cheliped length or in length of hand. It is indeed but little different from Alcock's smaller specimens in Ch.l. ÷ C.l., though in H.l. ÷ C.l. it exceeds his measurement (Nobili's specimen, C.l. = 27·0; Ch.l. = 70·0; H.l. = 20·0). Measurements taken as in *M. fugax*.

Myra brevimana, Alcock, 1896—A.2, p. 206; A. Invest., pl. xxix., fig. 8.

Locality:—Aripu coral reefs, Gulf of Manaar, four specimens (*a, b, d, h*); off Kaltura, four specimens (*c, e, f, i*); off Galle, two specimens (*g, j*).; Trincomalee, one specimen.

Description:—

	yg.	yg.	ad.	ov.	ad.	ad.	ad.	ad.	ad.
	b (♀).	*c* (♀).	*d* (♀).	*h* (♀)	*i* (♀).	*j* (♀).	*e* (♂).	*f* (♂).	*g* (♂).
C.l. (spine).	9·50	12·50	16·50	18·50	22·00	25·50	16·00	17·75	18·25
C.b. ÷ C.l.	0·87	0·84	0·83	0·84	0·84	0·84	0·84	0·85	0·79
Ch.l. ÷ C.l.	1·53	1·60	1·67	1·70	1·76	1·75	1·91	1·85	1·88
H.l. ÷ C.l.	0·34	0·38	0·41	0·43	0·43	0·43	0·48	0·45	0·47
F.l. ÷ H.l.	1·00	0·95	0·89	0·84	0·89	0·86	0·77	0·84	0·82
H.l. ÷ H.b.	1·86	1·90	2·08	2·14	1·89	1·84	2·21	2·00	2·00

Variability in size of adults is high. The two smallest specimens have a few scattered hairs. There is a suggestion in the adults of sexual dimorphism as regards

cheliped length. Specimen (*h*), though female, has well-marked spinule on penultimate abdominal tergum. Measurements taken as in *M. fugax*.

Myra darnleyensis, HASWELL, 1879—A.2, p. 207.

Localities:—Aripu coral reefs, Gulf of Manaar, four specimens; pearl banks, three specimens.

Description:—There are in all considerable traces of the "cruciform constellation" of five enlarged granules on centre of dorsum of carapace. This is evidently not confined to females and young males, as it occurs in an adult male from "pearl banks."

Leucosia obtusifrons, DE HAAN, 1841—A.2, p. 216.

Localities:—Aripu coral reefs, Gulf of Manaar, two specimens (*a*, *b*); off Kaltura, one specimen (*c*).

Description:—

	(*a*) young ♂.	(*b*) young ♂.	(*c*) adult ♂.
C.l.	12·75	17·25	25·00
C.b. ÷ C.l.	0·90	0·91	0·92
Ch.l. ÷ C.l.	1·10	1·20	1·45

In addition to the two pairs of white gastric spots characteristic of the species there is a third pair of quite small but otherwise similar ones, anteriorly. In specimen (*a*) young male all these spots are faintly ringed and a pair of postero-lateral orange spots is present also.

Leucosia longifrons, DE HAAN, 1841—A.2, p. 217.

Localities:—Trincomalee, two specimens (*a*, *b*); pearl banks, Gulf of Manaar, one specimen (*d*); Station I., off Negombo, one specimen (*c*); Aripu Reef, one specimen (*e*).

Description:—

	(*a*) young ♀.	(*b*) young ♂.	(*c*) young ♀.	(*d*) young ♀.	(*e*) adult ♀.
C.l.	17·00	17·50	17·50	17·75	26·00
C.b. ÷ C.l. . .	0·85	0·87	0·87	0·87	0·87

Specimen (*c*) young female comes under var. *pulcherrima*. Specimens (*a*) young female and (*b*) young male show some tendency to vary in the direction of the same variety (anterior half of carapace is slightly punctate); propodites of walking legs carinate dorsally and tend to be so ventrally also, each of the posterior two of the six spots of gastric shoe is surrounded by red rings.

On the other hand, var. *neocalidonica* characters are hinted at in specimens (*d*) young female and (*e*) adult female, where in addition to dorsal and ventral carination of propodites of the walking legs, common to *pulcherrima* and *neocalidonica*, the chelæ and walking legs have a tendency to the granulation of the latter variety. Thus in (*e*) adult female the wrist has trace of the three granules, the meropodite of walking leg 1 has traces of one dorsal and one ventral row, and that of walking leg 2 has traces of one dorsal row of granules.

Leucosia urania, Herbst, 1801—A.2, p. 220.

Locality :—Galle, one specimen.

Description :—Young male, C.l. = 17·00 ; C.b. ÷ C.l. = 0·84.

A series in the British Museum links this specimen with the adult form, from which latter it differs in certain points :—(1) fingers are crenulate in their distal half only ; (2) hand is cristate on both borders (the lower crest is crenulate—the crenulations swollen into granules).

Leucosia cumingi, Bell, 1855—A.2, p. 226.

Locality :—Coral reefs, Gulf of Manaar, one specimen.

Description :—Ovigerous female, C.l. = 13·00 ; C.b. ÷ C.l. = 1·04.

Leucosia hæmatosticta, Adams and White, 1848—A.2, p. 229.

Localities :—Aripu coral reefs, Gulf of Manaar, two specimens (*b*, *c*) ; Station I., off Negombo, one specimen (*a*).

Description :—	(*a*) male.	(*b*) ovigerous female.	(*c*) ovigerous female.
C.l.	9·75	13·00	13·50
C.b. ÷ C.l. . . .	0·97	1·00	0·98

Leucosia pubescens, Miers, 1877—A.2, p. 233.

Localities :—Galle, one specimen ; pearl banks, Gulf of Manaar, three specimens ; coral reefs, Gulf of Manaar, three specimens.

In an ovigerous female, C.l. = 18·50.

Philyra platychira, de Haan, 1841—A.2, p. 242.

Localities :—Coral reefs, Gulf of Manaar, four specimens ; pearl banks, three specimens ; Trincomalee, three specimens ; Welligam Bay, two specimens ; Galle, six specimens.

An indication of sexual dimorphism is given by index Ch.l. ÷ C.l. :—

For 12 adult males this has mean value 2·32 and range of variation 2·23–2·40.

,, 4 ,, females ,, ,, . 1·83 ,, ,, 1·67–1·92.

To this difference all the segments of the cheliped contribute. Thus

	Arm l. ÷ C.l.	Wrist l. ÷ C.l.	H.l. ÷ C.l.	F.l. ÷ C.l.
Male means	0·93	0·32	0·60	0·47
Female means . . .	0·71	0·26	0·51	0·35

All have some very fine granulation on the posterior and lateral regions of the dorsum of the carapace—the specimens from "Coral reefs, Gulf of Manaar," have in addition some rather large scattered granules on the lateral region.

Some of the specimens fall under Klunzinger's var. *bidentata* (K., p. 72).

Philyra adamsi, BELL, 1855 ('Trans. Linn. Soc.,' xxi., p. 301)—Plate I., fig. 1.

Localities:—Pearl banks, Gulf of Manaar, two specimens; coral reefs, Gulf of Manaar, four specimens, including (*b*); Galle, seven specimens, including (*a*).

Description:—	C.l.	C.b. ÷ C.l.	Ch.l. ÷ C.l.	H.l. (upper border) ÷ C.l.	Fixed finger (inner border) ÷ C.l.
(*a*) Ovigerous ♀	8·00	1·02	1·60	0·34	0·26
(*b*) Adult ♂	9·00	1·03	2·10	0·46	0·36
(*c*) BELL'S "type," ♂ .	9·00	1·03	2·25	0·50	0·39

I have compared the specimens with BELL'S "type" preserved in the British Museum, and they agree well with it.

BELL'S figure gives an inadequate, and in some respects erroneous, idea of his specimen. HENDERSON amends BELL'S description (H., p. 400), but omits reference to any hepatic facet, the presumed *absence* of which has been lately emphasised by NOBILI (N., p. 104). In re-figuring BELL'S specimen I emphasise (1) general shape of front; (2) presence of a small median frontal tooth, at lower level than rest of front; (3) details of hepatic facet; (4) two tubercles on hand at base of fixed finger; (5) proportions of buccal cavern; (6) exognath of external maxilliped.

Remarks:—ALCOCK omits this species from his key, observing that it appears to him to be rather a *Pseudophilyra*. It is indeed intermediate in many ways, *e.g.*: (1) production of front; (2) general proportions of buccal cavern; (3) shape of exognath of external maxilliped. But in all these particulars it bears considerable resemblance to *Philyra platychira* and to *Ph. granigera*, NOBILI, 1906 (N., p. 102, pl. vi., fig. 30), both of which it further resembles in the presence of the hepatic facet and of the longitudinal grooves of the carapace (the latter more as *P. granigera* than *P. platychira*). It must be placed in the same genus with these, and all three fall under section I.2.1 of ALCOCK'S key of *Philyra*.

Ph. adamsi is at once distinguished from *Ph. platychira* by the entire sub-orbital border of the endostome and by the characters of hand and fingers.

It is more closely allied to *Philyra granigera* than NOBILI imagined, since it has in reality a hepatic facet. It differs from *Ph. granigera* in possessing:—(1) line of granules on upper border of inner surface of hand and wrist; (2) the distinct granule on upper surface of hand proximal to base of fixed finger (tendency for a second, less distinct granule just distal to the distinct one); (3) the small median frontal tooth.

Philyra globosa (FABR.), 1787—A.2, p. 243.

Localities:—Trincomalee, one specimen (immature male); Galle, two specimens (adult females).

Pseudophilyra tridentata, MIERS, 1879—A.2, p. 250.

Locality:—Pearl banks, Gulf of Manaar, five specimens (*a*, *b*, *c*, *d*, *e*).

Description:—	(*a*) ad. ♂.	(*b*) ad. ♂.	(*c*) ad. non.-ov. ♀.	(*d*) ovig. ♀.	(*e*) ovig. ♀.
C.l.	5·00	5·00	5·50	6·00	6·00
C.b. ÷ C.l. . .	0·85	0·90	0·86	0·92	0·92
Ch.l. ÷ C.l. . .	1·60	1·60	1·45	1·50	1·46
F.l. ÷ H.l. . .	0·50	0·50	0·50	0·54	0·54
H.b. ÷ H.l. . .	0·50	0·50	0·50	0·54	0·54

The specimens are much smaller than those in the Indian Museum from Persian Gulf. The length of the first pair of walking legs exceeds that of the arms by about the last segment only, as NOBILI (N., p. 105) found in his Persian Gulf specimens. H.b. ÷ H.l. is of same order as ratio recorded by NOBILI and by CALMAN (C., p. 28).

There is no distinct abdominal tooth in the males; just a slight convexity in (*a*) adult male, more marked in (*b*) adult male.

Pseudophilyra melita, DE MAN, 1888—A.2, p. 253.

Localities:—Trincomalee, six specimens; coral reefs. Gulf of Manaar, one specimen; pearl banks, Gulf of Manaar, four specimens.

Description:—*d*, *g*, *h*, *j*, adult.

	(*a*) yg. ♂.	(*c*) yg. ♂.	(*d*) ♂.	(*g*) ♂.	(*h*) ♂.	(*j*) ♂.	(*b*) yg. ♀.	(*e*) ♀ ov.	(*f*) ♀ ov.	(*i*) ♀ ov.	(*k*) ♀ ov.
C.l. . . .	8·75	9·50	9·75	10·25	12·75	13·50	9·00	9·75	10·00	13·00	13·75
C.b. ÷ C.l.	0·88	0·89	0·87	0·88	0·90	0·89	0·92	0·90	0·92	0·88	0·91
Ch.l. ÷ C.l.	1·94	1·89	1·87	1·93	1·90	1·96	1·67	1·67	1·67	1·71	1·71
H.b. ÷ H.l.	0·50	0·48	0·50	0·50	0·52	0·50	0·53	0·53	0·50	0·52	0·50

Sex difference negligible in C.b. and in H.b., but marked in Ch.l.

C.b. ÷ C.l. . . .	Mean adult	♂ = 0·89;	range of variation	♂	= 0·87–0·91
	,,	♀ = 0·90;	,, ,,	♀	= 0·88–0·92
H.b. ÷ H.l. . .	,,	♂ = 0·50;	,, ,,	♂	= 0·50–0·52
	,,	♀ = 0·51;	,, ,,	♀	= 0·50–0·53
Ch.l. ÷ C.l. . .	,,	♂ = 1·91;	,, ,,	♂	= 1·87–1·96
	,,	♀ = 1·69;	,, ,,	♀	= 1·67–1·71

Heterolithadia fallax (HENDERSON), 1893—A.2, p. 261.

Localities:—Pearl banks, Gulf of Manaar, two specimens (*a*, *e*); coral reefs, Gulf of Manaar, two specimens (*b*, *d*); Trincomalee, one specimen (*c*).

Description:—	(*a*) young ♂.	(*b*) young ♂.	(*c*) ovigerous ♀.	(*d*) ♀.	(*e*) ovigerous ♀.
C.l. . . .	9·00	11·25	13·00	15·00	17·50
C.b. ÷ C.l. .	1·06	1·02	1·04	1·03	1·03
Ch.l. ÷ C.l.	1·58	1·53	1·50	1·43	1·44
F.l. ÷ H.l. .	1·50	1·47	1·45	1·40	1·48
H.b. ÷ H.l.	0·75	0·73	0·66	0·70	0·70

The gastro-cardiac groove is very inconspicuous in all.

Arcania quinquespinosa, Alcock and Anderson, 1894—A.2, p. 266.

Locality :—West of Periya Paar, 17 to 24 fathoms, one specimen.

Description :—Adult female, C.l. = 11·00 (includes frontal lobes, but not posterior spine); C.b. (without spines) ÷ C.l. = 1·05; lateral spine l. ÷ C.l. = 3·41; Ch.l. ÷ C.l. = 2·23; F.l. ÷ H.l. = 1·50. The pair of postero-lateral granules is present.

Arcania erinaceus (Fabricius), 1787—A.2, p. 268.

Localities :—Pearl banks, Gulf of Manaar, two specimens (*a*, *c*); coral reefs, Gulf of Manaar, one specimen (*b*).

Description (measurements as in *A. quinquespinosa*) :—

	(*a*) young ♀.	(*b*) ad. ♂.	(*c*) ad. ♀.
C.l.	13·25	18·50	18·75
C.b. ÷ C.l.	0·87	0·84	0·88
Ch.l. ÷ C.l.	1·55	1·57	1·49
F.l. ÷ H.l.	0·73	0·59	0·61

A difference between the adult male and the adult female above is the presence in the latter of a median longitudinal line of hair on the ischium of the external maxilliped.

Arcania tuberculata, Bell, 1855—A.2, p. 268.

Locality :—Pearl banks, Gulf of Manaar, two specimens (*a*, *b*).

Description :—	C.l.	C.b. ÷ C.l.	Ch.l. ÷ C.l.	F.l. ÷ H.l.
(*a*) ovigerous ♀ . . .	9·50	0·89	1·18	0·77
(*b*) ovigerous ♀ . . .	10·25	0·88	1·17	0·85

Arcania pulcherrima, Haswell, 1879—A.2, p. 269.

Localities :—Trincomalee, one specimen (*a*); coral reefs, Gulf of Manaar, one specimen (*b*).

Description :—	C.l.	C.b. ÷ C.l.	Ch.l. ÷ C.l.	F.l. ÷ H.l.
(*a*) young ♂	8·00	1·09	2·06	0·82
(*b*) ovigerous ♀ . . .	10·75	1·09	2·16	0·77

There are in both specimens 14 tubercles on the dorsal surface of the carapace in addition to the 10 marginal prominences.

Ixa cylindrus (Fabricius), 1787—A.2, p. 271.

Localities :—Aripu Reef, one specimen (*a*); pearl banks, Gulf of Manaar, one specimen (*b*).

Description (lateral spines included in C.b.) :—	(*a*) ad. ♂.	(*b*) ad. non-ov. ♀.
C.l.	14·50	16·75
C.b. ÷ C.l.	2·83	2·88

Dorippe dorsipes (Linnæus), 1764—A.2, p. 277.

Localities :—South end of Cheval Paar, two specimens ; Pearl banks, Gulf of Manaar, six specimens ; Coral reefs, Gulf of Manaar, five specimens ; Galle, one specimen.

Description :—There are no ovigerous females ; probably none of the females are adult. Of the males perhaps two or three of the largest specimens are adult. The largest male has C.l. = 23·50, *i.e.*, two-thirds measurement given by Alcock for large male. In the smallest specimens (C.l. = 8·50 and 9·00) the spine at outer angle of orbit falls far short of level of frontal teeth ; it nearly reaches it in larger specimens ; in the largest of all (C.l. = 23·50) it quite does so. In Alcock's still larger specimens it projects beyond the frontal teeth. In an immature male (C.l. = 12·00) from " Pearl Banks, Gulf of Manaar," there is on abdominal tergum IV. a small acute tubercle on either side of the larger median tubercle. The hands are still symmetrical in a male whose C.l. = 18·00.

Dorippe facchino (Herbst), 1785—A.2, p. 278.

Locality :—Pearl banks, Gulf of Manaar, two specimens.

Description :—	C.l.	C.b. ÷ C.l.	2nd W.L. ÷ C.l.	2nd W.L. ÷ 4th W.L.
(*a*) Young male . .	10·25	1·10	3·25 (approx.)	2·50 (approx.)
(*b*) ,, ,, . .	10·25	1·12	—	—

In neither does the spine at the external orbital angle project so far forward as the level of the frontal teeth. They are less hairy than Alcock describes for the adult ; hair is entirely absent from walking legs 1 and 2. In this respect they suggest the specimens included by Alcock as " ? *D. granulata*, de Haan " (A.2, p. 279).

Raninoides serratifrons, Henderson, 1893—A.2, p. 293.

Localities :—South of Galle, deep water, three specimens ; west of Periya Paar, 17 to 24 fathoms, four specimens.

Description :—All are apparently immature. C.l. ranges from 6·50 to 15·25.

OXYRHYNCHA.

Achæus lacertosus, Stimpson, 1857—A.1, p. 172.

Localities :—Aripu coral reefs, Gulf of Manaar, two specimens (adult ♂) ; pearl banks, Gulf of Manaar, one specimen (adult ♂).

Description :—C.l. (exclusive of rostrum) of an adult male = 11·00.

Achæus dubia, n. sp.—Text-fig. 3.

Localities :—Pearl banks, Gulf of Manaar, four specimens (*a*, *d*, *f*, *g*) ; Chilaw Paar, one specimen (*e*) ; west of Periya Paar, 17 to 24 fathoms, one specimen (*b*) ; off Negombo, Gulf of Manaar, one specimen (*c*).

Description:—	(*a*) ad. ♂.	(*b*) ov. ♀.	(*c*) ov. ♀.	(*d*) ov. ♀.	(*e*) ov. ♀.	(*f*) ov. ♀.	mean ov. ♀.
C.l.	10·25	8·75	9·00	10·00	10·00	11·00	9·75
Rostrum l. ÷ C.l. . .	0·20	0·17	0·14	0·15	0·19	0·18	0·19
C.b. ÷ C.l.	0·78	0·86	0·75	0·82	0·87	0·84	0·83
Anten.flag.l. ÷ C.l. . .	0·83	—	0·67	—	0·75	0·75	0·72
Post.bord.C. ÷ C.l. . .	0·32	0·46	0·42	0·45	0·45	0·45	0·45
Arm.l. ÷ C.l.	0·78	0·51	0·44	0·50	0·55	0·50	0·50
Wrist.l. ÷ C.l. . . .	0·59	0·37	0·32	0·37	0·40	0·36	0·37
H.l. (up. bord.) ÷ C.l. .	0·73	0·37	0·33	0·37	0·40	0·36	0·37
H.b. ÷ C.l.	0·36	0·11	—	0·11	0·12	0·11	0·11
F.l. ÷ C.l.	0·54	0·40	0·36	0·42	0·47	0·41	0·41
W.L.1.Isch.l. ÷ C.l. . .	0·39	0·34	0·31	0·30	0·35	0·32	0·32
,, Merop.l. ÷ C.l. .	2·10	1·46	1·31	1·47	1·70	1·36	1·46
,, Carp.l. ÷ C.l. .	0·93	0·70	0·61	0·70	0·75	0·64	0·68
,, Prop.l. ÷ C.l. .	2·00	1·49	1·39	1·42	1·72	1·45	1·49
,, dact.l. ÷ C.l. . .	—	—	0·97	—	—	1·05	1·01

The division between carapace and rostrum is taken to be a line uniting the anterior borders of the orbits; C.b. = a straight line uniting points above base of W.L.1 of either side, which is the region of greatest breadth; posterior border of carapace = a straight line uniting points behind the lateral tubercles of the posterior border; cheliped segments and segments of W.L.2 are measured along upper edge.

Description of Ovigerous Female (*f*).—Carapace sub-triangular, the postero-lateral angles well rounded, and the posterior border concave. The rostral lobes appear to the naked eye to be united to form a single short median dorsally grooved and bluntly pointed projection which reaches forward about as far as the distal end of the first joint of the antennal flagellum. The carapace is narrowed laterally behind the eyes. There is a post-hepatic constriction due to the branchio-cardiac groove. The greatest breadth is in the region above the first pair of walking legs. The regions of the carapace are distinct. The carapace armature consists of (1) tubercles, (2) straight hairs, (3) hooked hairs. The general surface beneath the hairs is smooth; of the tubercles two at once attract the eye—a large conical gastric one and a still larger one on the cardiac region. The tubercles are in detail:—3 gastric, arranged in form of a triangle, of which the two anterior ones, forming the base, are inconspicuous, while the median posterior one is that already mentioned—1 cardiac (median), the

Fig. 3. *Achæus dubia*, n. sp.

largest on the animal and already mentioned—3 branchial (paired), of which one is lateral while the other two are dorsal, and so placed that a straight line uniting them would on being produced anteriorly pass between the antero-lateral gastric tubercle of the same side and the median gastric tubercle—2 hepatic tubercles (paired), a larger one below and to the outer side of a smaller—1 sub-hepatic (paired)—1 buccal, *i.e.*, the produced antero-external angle of the buccal cavern (paired)—1 pre-buccal tubercle (paired), quite small, just anterior to and a little above the buccal tubercle, its apex points downwards and outwards—finally, 1 at either end of posterior margin of the carapace. The buccal, the sub-hepatic, and the lateral branchial tubercles on either side are united by a low ridge forming an approximately straight line.

The upper margin of the orbit is smooth, there is no dorsal spine in this region.

The sternal surface is devoid of spinules.

Each tubercle tends to be crowned by one or two hairs of the straight variety. A dorso-lateral longitudinal row of hooked hairs is conspicuous on the branchial regions of either side; it commences on the region above the base of walking leg 3 and runs forward below the two dorsal branchial tubercles. On the anterior half of the carapace the hooked hairs are numerous and tend to run in lines which converge anteriorly.

The abdomen has in both sexes six divisions, somite VI. and telson being as usual fused. On its tergal surface are both straight and hooked hairs.

The basal antennal joint is smooth and fixed, being fused distally to the front. The antennal flagellum is fringed feather-wise with long straight hairs.

In the external maxillipeds the inner edge of the ischium and of the merus is fringed with long straight hairs. The inner edge of the ischium is finely toothed and its exposed surface tends to be roughened (under lens); the roughening is most marked along two slight longitudinal carinæ which border a somewhat V-shaped median longitudinal depression. The merus also is grooved longitudinally.

In the chelipeds the under border of the ischium and of the merus, and the upper and under borders of the laterally compressed hand, are carinate and finely denticulate; the denticulation is continued along the proximal half of the under border of the fixed finger. The rest of the cheliped is smooth. The fingers are strongly incurved and are apposable throughout their length. Long straight hairs fringe the upper and under borders of all the cheliped segments. Hooked hairs are arranged in a median longitudinal row on the outer surface of the arm; they occur also on the lower part of the outer surface of the wrist and on the upper portion of the outer surface of the hand.

The dactylopodites of walking legs 3 and 4 are slightly falciform, the curve strongest proximally. The walking legs possess some long scattered straight hairs. A row of hooked hairs is present on the upper border of all the segments of all the walking legs except the dactylopodites of the last two pairs.

Variation among the ovigerous females concerns (1) the size but not the number of

Camposcia retusa, Latreille, 1829—A.1, p. 184.

Locality :—Pearl banks, Gulf of Manaar, one specimen.

Description :—Male, apparently adult, C.l. = 23·50. It has the broad sternum (Klunzinger, pl. i., fig. 1) and slender cheliped described for males of this species, giving them a curiously female appearance. The sternum, though broad in the male of this species, is not so broad as in the female.

Apocremnus indicus, Alcock, 1895—A.1, p. 188; A.Invest., pl. xx., fig. 1.

Localities :—Coral reefs, Gulf of Manaar, sixteen specimens; south of Galle, deep water, six specimens; Gulf of Manaar, deep water, three specimens.

Description :—In an ovigerous female C.l. (excluding rostrum) = 7·00. A gastric spinule is present—this is figured by Alcock, but omitted from his description.

A post-ocular spinule is figured by Alcock in his ventral view of the male, but is said by him in his description to be absent. The description—not the figure—is correct for the present specimens.

There is evidence in the present specimens that the male of this species is facultatively dimorphic. The series includes what I believe to be examples of young, non-breeding, and breeding males—the latter I judge to be of the "low" type.

Xenocarcinus tuberculatus, White, 1847, var. **alcocki**, nov.—A.1, p. 192.

Locality :—Dutch Modragam Paar, one specimen.

Description :—An ovigerous female. C.l. (excluding rostrum) = 12·50; Rost.l. ÷ C.l. = 0·32. The present specimen agrees with A. Milne-Edwards' fig. 1 ('Archiv. du. Mus.,' viii., 1872, p. 253, pl. xii., figs. 1 to 1*g*) in character of its legs, and is fairly intermediate in carapace-character between this and White's "type"-specimen in British Museum which is figured by Miers ('Zool. Erebus and Terror,' Crust., p. 1, pl. ii., figs. 1 to 1*e*). It thus agrees in general appearance with Alcock's figure of a specimen from Andamans or from Ceylon, but the rostrum is narrower anteriorly and so more conical. A close examination of the carapace surface reveals some obsolescent tubercles in the position of those seen in A. Milne-Edwards' fig. 1, but are not sufficiently developed to affect the general appearance, which is due rather to nine swellings as in White's "type"-specimen; they are not, however, so strongly developed, so conical, nor so pointed as in the latter, and in particular the gastric and cardiac eminences are very ill-developed.

Remarks.—No second example seems to have been described which is in agreement with White's "type"-specimen (female) of *X. tuberculatus*. I have examined the five British Museum specimens from Cape Howe, for which Miers created *X. depressus* in 1874 (reference as above), and find that they come into the series figured by A. Milne-Edwards; one of them in particular is well represented by his fig. 1. Calman states (p. 34) that his Murray Island male is in fair agreement with the same figure.

Alcock describes. There is a difference between the sexes in rostral length. Thus the measurements show that for 6 males the mean value of R.l. ÷ C.l. = 0·41, and range of variation = 0·36–0·45. For 10 females the corresponding figures are 0·32 and 0·29–0·33. Neither the slight variation among the female nor the considerable variation among the male specimens seems to be particularly associated with growth.

Simocarcinus simplex (Dana), 1852, var. **pyramidatus**, nov.—A. I. p. 196.

[**Huenia hellerii**, Paulson, 'Crustacea of the Red Sea' (Russian), Kiev, 1875, p. 8, pl. iii., figs. 2*a* to *c*.] **Trigonothir pyramidatus**, Klunzinger, p. 19, pl. i., figs. 3 to 3*g*.

Localities:—Jokkenpiddi Paar, three specimens (*a*, *b*, *d*); south end of Cheval Paar, one specimen (*e*); coral reefs, Gulf of Manaar, one specimen (*f*); pearl banks, Gulf of Manaar, four specimens (*g*, *h*, *i*, *j*); off Mutwal Island, one specimen (*c*).

Description:—

	In present collection.				*S. simplex* in British Mus.				
	(*a*)ad. ♂.	(*b*)ad. ♂.	(*c*)ad. ♂.	(*e*).	(*m*) ♂.	(*n*) ♂.	(*o*)ad. ♀.	(*p*)ad. ♀.	(*q*)ad. ♀.
C.l.	16·00	16·00	12·25	14·00	15·50	13·50	14·75	12·00	12·00
R.l. ÷ C.l.	0·95	0·87	0·98	0·57	0·32	0·41	0·20	0·33	0·31
C.b. ÷ C.l.	0·86	0·91	0·82	0·89	0·97	0·93	0·95	1·00	1·00
Inter-orb.b. ÷ C.l. . .	0·25	0·25	0·29	0·30	0·26	0·30	0·27	0·29	0·29
Ch.l. ÷ C.l.	1·97	1·95	1·65	1·19	1·68	1·43	—	1·19	1·12
W.L.1.l. ÷ C.l. . . .	2·42	—	2·27	2·05	1·94	1·87	—	—	1·75
W.L.2.l. ÷ C.l. . . .	1·12	—	1·12	—	1·16	1·09	1·00	1·12	1·17
W.L.4.l. ÷ C.l. . . .	0·83	0·95	—	—	0·85	0·85	0·86	0·98	0·96

All the specimens have three tubercles on the gastric region of the carapace; they are somewhat blunter in the female than in the male.

The rostrum exhibits variability in several respects: (1) In its length, as above; (2) it may be straight or curved, in the latter case the concavity is below; (3) it may arise from the front of the carapace in such a way as to continue the general horizontal plane of the dorsal surface of the carapace, or it may rise upwards somewhat and make an obtuse angle with that plane. In one male the rostrum is straight and its plane horizontal; in two males it is curved and makes an obtuse angle with the post-rostral carapace.

The hands of one male are massive, with fingers which are only apposable at their tips, and which are, when so apposed, separated at the base by a considerable space; in two other males the hands are slender and the fingers when apposed distally are almost in contact basally.

A lobe is present in all the specimens on either side of the posterior border of the carapace. The size of the lobes is intermediate between those of dried specimens of *S. simplex* in the British Museum and Heller's figure of *pyramidatus*.

The eye is much as in the British Museum specimens of *simplex*, *i.e.*, less prominent than in Dana's figure. In each of the three females which I place with the above males there is a pair of hepatic lobes,

Remarks.—The present specimens form a group which I believe breaks down the distinction between *Simocarcinus simplex* (DANA), 1852, and *S. pyramidatus* (HELLER), 1861. As set forth by ALCOCK, the characters by which the former is distinguished from the latter are (1) the much shorter rostrum of the male; (2) the presence of three tubercles, disposed in a triangle, on the gastric region; (3) the larger and more prominent eyes; (4) the absence of the lobule on either side of the posterior border of the carapace; (5) the much more massive chelipeds of the male.

In the first place, I may remark that the only other specimen which appears to agree with the single one for which HELLER created *pyramidatus* is the male described by ALCOCK. I have examined MIERS' specimens of *S. simplex* in the British Museum and find that, though they are evidently *S. simplex* in the narrower sense of the term, they show two points of difference from DANA's figure which diminish the value of distinctions (3) and (4) above. There is in each of them a lobe at either end of the posterior border (it is distinct, though not so large as in HELLER's figure of *S. pyramidatus*), and in all the males the eyes are less prominent than in DANA's figure. This doubt cast upon the value of distinctions (3) and (4) is confirmed by the present specimens (see description above). The fifth distinction seems, in view of the evidence of the specimens in the present collection, to be one between young and adult males or between non-breeding and breeding adults. There is, however, some difference between the massive chela of male specimens (*a*) and (*b*) of the present examples and that of the British Museum male (*m*); this may or may not be a difference associated with high and low males respectively. Of ALCOCK's two remaining distinctions, (1) and (2), each specimen of the present group unites the three gastric tubercles of *S. simplex* with the long rostrum of *S. pyramidatus*. CANO ('Boll. Soc. Nat. Napol.,' iii., 1889, p. 173) describes an animal with a similar combination and unites the two species. More recent writers have not followed him, and KLUNZINGER (p. 19) describes a similar male as *pyramidatus*. The additional evidence confirms CANO.

It is difficult to estimate the value of the character rostrum-length referred to above. It holds excellently as between the present individuals and the specimens labelled *S. simplex* in the British Museum (see measurements above); but in KLUNZINGER's figure the index R.l. ÷ C.l. seems to be about 0·62, and HENDERSON describes his specimens as *simplex*, but with longer rostrum. The high variability of this character in *S. camelus*, KLUNZINGER (1906, pl. i., figs. 2*a*–*g*), is to be borne in mind. A further point of difference between my specimens and the British Museum examples of *S. simplex* is the greater length of the first pair of walking legs in the former (see measurements above, under W.L.1.l. ÷ C.l.). The present forms and all those with the three gastric tubercles I name var. *pyramidatus*.

I consider that MIERS' distinction between *Simocarcinus* and *Trigonothir* (the latter genus formed for a single male specimen) must be given up. The slender cheliped of the latter is better considered as the character of a young or of a non-breeding

individual. The rostrum is stouter, more swollen and more clumsy in *Trigonothir* than in *Simocarcinus simplex* (includes *S. pyramidatus*) and *S. camelus*, but it is essentially the same otherwise. In all these its under surface is flattened proximally, while distally it is concave and produced into lateral carinæ; and its apex tends to be three-lobed, the lobes set at angles of 120° (very approximately) to each other. I have seen no specimens of *Simocarcinus* with the laterally compressed acute rostrum given by MIERS as a generic character. KLUNZINGER (p. 18) revises MIERS' definition of *Trigonothir*, transferring to it the species *pyramidatus*. As a new generic character he gives the absence of hepatic lobes in the female. The evidence of the present specimens confirms me in doubting the validity of this. As another new generic distinction he points out that in *Trigonothir* the chelipeds of the adult male are unequal. With the additional evidence available to me, I would suggest that this inequality—observed only in a single example (KLUNZINGER, pl. i., fig. 3)—is due to regeneration. I unite *Simocarcinus* and *Trigonothir* under the name of the former and for the present distinguish this genus from *Huenia* by two characters:—

(1) Pre-ocular spine. This is present in *Huenia*, absent in *Simocarcinus*. (2) Rostrum. In *Huenia* this is sharp-edged below and has an acute tip; in *Simocarcinus* it has a flattened under surface which tends to be concave distally, where its lateral edges are produced—the tip of the rostrum tends to be trilobed.

Menæthius monoceros (LATREILLE), 1825—A.1, p. 197.

Localities:—Cheval Paar, Gulf of Manaar, seven specimens (*h*, *f*, *g*, &c.); Aripu coral reefs, ten specimens (*c*, *a*, *e*, *i*, &c.); off Mutwal Island, eight specimens (*j*); Jokkenpiddi Paar, two specimens (*b*, *d*); Navakaddu Paar, one specimen.

Description:—

Males.	(*a*).	(*b*).	(*c*).	(*d*).	(*e*).	(*f*).	(*g*).	(*h*).	(*i*).	(*j*).
C.l. . . .	6·00	7·00	7·50	9·25	9·50	9·75	10·25	12·00	14·25	15·00
R.l. ÷ C.l. .	0·58	0·50	0·37	0·49	0·55	0·51	0·51	0·66	0·72	0·77

Ovig. females.	(*k*).	(*l*).	(*m*).	(*n*).	(*o*).	(*p*).	(*q*).	(*r*).	(*s*).
C.l.	9·75	9·75	9·75	10·25	10·75	12·00	12·25	13·25	13·50
R.l. ÷ C.l. . .	0·32	0·49	0·51	0·59	0·44	0·50	0·43	0·43	0·50

The first three of the above males are young; there is evidence in the collection that this is a species showing facultative dimorphism.

The specimens show considerable variation in number of tubercles on dorsal surface of the carapace and in the teeth of the lateral border. The majority resemble the variety figured by DANA as *Menæthius sub-serratus* rather than any other variety. Some tend to combine the characters of two or more of DANA's figures, *e.g.*, of the three specimens from Cheval Paar, one agrees fairly with the figure of *M. sub-serratus*, while the other two agree with this figure in character of lateral teeth, but more resemble that of *M. angustatus* in tuberculation. The two specimens from Jokkenpiddi agree fairly with DANA's figure of *M. tuberculatus*.

Variability of rostrum-length is high. Thus for eight ovigerous females the index R.l. ÷ C.l. has mean value = 0·47, and range of variation from 0·32 to 0·59. For the ten males of various ages the corresponding figures are 0·57 and 0·37–0·77.

Specimen *s* (female) stands apart from the others and makes some approach to *Huenia proteus* in the character of its last pair of walking legs. These are comparatively smooth and expanded, and obvious teeth are absent from the dactylopodite. This specimen also has dorso-lateral hepatic swellings.

Acanthonyx macleayi, Krauss, 1843—A. 1, p. 199.

Locality:—Cheval Paar, Gulf of Manaar, one ovigerous female. C.l. = 12·50.

Halimus pleione (Herbst), 1803—A. 1, p. 208.

Localities:—Pearl banks, Gulf of Manaar, two specimens (ovigerous ♀ *a*, *c*); off Mutwal Island, two specimens (ovigerous ♀ *b* and young ♂ *d*).

Description:—	(*a*) ovigerous ♀.	(*b*) ovigerous ♀.	(*c*) ovigerous ♀.	(*d*) young ♂.
C.l.	17·00	20·00	23·00	11·00
C.b. ÷ C.l. . . .	0·75	0·75	0·78	0·80
R.l. ÷ C.l. . . .	[ ]	0·37	0·31	0·41

In the immature male the rostral spines lie in an approximately horizontal plane; in the three ovigerous females they continue the downward anterior slope of the gastric region of the carapace.

Halimus hilgendorfi (de Man), 1888—A. 1, p. 209.

Localities:—Pearl banks, Gulf of Manaar, sixteen specimens (including *d* and *f*); Aripu coral reefs, Gulf of Manaar, eighteen specimens (including *a*, *b*, *c*, *g*, and *e*); off Mutwal Island, two specimens (*h*, *i*).

Description:—	(*a*) ov. ♀.	(*b*) ov. ♀.	(*c*) ov. ♀.	(*d*) ov. ♀.	(*e*) ad. ♂.	(*f*) ad. ♂.	(*g*) ad. ♂.	(*h*) ad. ♂.	(*i*) ad. ♂.
C.l.	11·50	13·50	14·00	16·50	12·50	12·50	13·50	14·50	15·00
Rost. spine l. ÷ C.l. .	0·32	0·44	0·41	0·25	0·52	0·56	0·52	0·52	0·55
D. tips R.sp. ÷ C.l.	0·20	0·33	0·30	0·23	0·42	0·28	0·40	0·34	0·47

The above measurements give an indication of the high variability of the length, and degree of divergence, of the rostral spines. Both the characters named are sexually dimorphic.

A sexual difference is also shown in carapace length.

Halimus spinosus (A. Milne-Edwards), 1872—A. 1, p. 211.

Locality:—Aripu coral reefs, Gulf of Manaar, three specimens (two young ♀ and young ♂).

Remarks.—I unite *H. consobrinus*, A. Milne-Edwards, and *H. spinosus* specifically. The slight points of difference are that in the former (1) the anterior angle of the

supra-ocular eave is hardly so much produced; (2) the two gastric spines are not so long: (3) the intestinal tubercle is but slightly represented. The present examples belong to the *consobrinus* variety.

Halimus convexus (MIERS), var. **hendersoni,** nov.

Localities:—Coral reefs, Gulf of Manaar, two specimens (ovigerous ♀ and young ♂); west of Cheval Paar, two specimens (young ♂); Cheval Paar, three specimens (young ♀).

Description:—C.l. of the ovigerous female = 10·50.

They differ from MIERS' form ('"Alert" Expedition,' p. 196 and figure) in having (1) an epibranchial tubercle on either side; (2) the carapace regions less strongly demarkated and less convex; (3) the rostral spines less divergent, straighter and shorter.

Remarks.—The specimens agree with the two dried ovigerous females from Penang in the British Museum, with which HENDERSON (p. 344) describes his Martaban example as almost identical. There is thus a group with a fairly wide distribution which differs from MIERS' form in certain definite respects: I call it var. *hendersoni.*

This variety bears a suspiciously close resemblance to descriptions and figures of *Halimus sub-inermis* (ZEHNTNER) ('Revue Suisse de Zool.,' ii., p. 136, pl. vii., figs. 2, 2*a*), and to *Halimus espinosus*, BORRADAILE (p. 688, pl. xlvii., fig. 4). I have not seen specimens of either of these species. The main difference from *Halimus espinosus* seems to be the form of the rostral spines. I should be inclined to merge both in *Halimus convexus* (MIERS).

Halimus brocki (DE MAN), 1887 ('Arch. f. Naturges.,' liii., p. 22).

Locality:—Off Mutwal Island, one specimen.

Description:—A male, perhaps adult. C.l. (measured anteriorly to the angle between the rostral spines) = 9·50; rostral spine l. ÷ C.l. = 1·0.

The rostral spines diverge less in their distal than in their proximal portions.

Halimus agassizi, RATHBUN, 1902—'Bull. Mus. Comp. Zool.' xxxix., p. 133, fig. 6.

Localities:—Pearl banks, Gulf of Manaar, one specimen (*a*); off Mutwal Island, one specimen (*b*); pearl banks, off Manaar, one specimen (*c*).

Description:—	(*a*) ovig. ♀.	(*b*) ovig. ♀.	(*c*) ad. ♀.
C.l.	8·50	6·00	6·50
R.l. ÷ C.l.	—	0·58	0·54

In specimen (*a*) there are a few inconspicuous hooked hairs, in no way hiding from view the tuberculation of the carapace, which I find to agree with Miss RATHBUN'S description of the male. The walking legs have a smooth appearance. In specimens (*b*) and (*c*) hooked hairs are numerous, obscuring the tuberculation of the carapace and giving the legs a roughened appearance.

As a point of distribution I may note that I found a specimen of this species (an

ovigerous female) in the bottle which contains POCOCK'S "type" specimen of *Hyastenus* (*Chorilia*) *tenuicornis*, labelled "China Sea."

The interesting little tooth of the supra-orbital margin is referred to under *H. irami*, n. sp.

Halimus pehlevi, n. sp.—Plate I, fig. 3, 3*a*.

Localities :—Coral reefs, Gulf of Manaar, two specimens (*f*, *g*); pearl banks, Gulf of Manaar, 15 specimens. One is a young female; six are adult females (five are ovigerous); five are young males; five are adult males.

Description of Adult Male (*g*).—Carapace sub-triangular, globular behind the lateral post-hepatic groove. The regions are distinctly defined, and are convex independently of the general convexity of the carapace, and bear certain granules :— a pair at the anterior border of the gastric region internal to the bases of the supra-ocular eaves; 13 posterior to these on the gastric region, of which three are median; one (median) between the gastric and cardiac regions; three on the cardiac region arranged as a triangle with its base turned forward; one (median) intestinal; one in the posterior portion of the groove on either side of the cardiac region; two on each branchial region. The true posterior border of the carapace is convex apart from the general outline of the carapace. The rostral spines are divergent, the distance between their tips divided by the length of one of them = 1·11. Length of rostral spine (inner border) ÷ carapace length = 0·39. The spines are bordered laterally with hooked hairs. The supra-ocular eave is strongly bilobed; the post-ocular tooth has a denticle about the middle of its anterior border. The pterygostomian region bears a couple of tubercles, one to outer side of and behind the other.

The antero-external angle of the basal antennal joint is produced into a stout tooth which is just concealed in a dorsal view of the animal. Behind it the outer border of the basal joint of the antenna presents a slight convexity which is produced ventrally a little. Posterior to this and external to the opening of the green gland is a prominent laterally compressed tubercle, and posterior to this again the antero-external angle of the buccal cavern forms a prominence. The four prominences just named form a longitudinal row. The antennal flagellum does not reach so far forward as the tip of the rostral spine; it is stout and bears a few thick hairs averaging somewhat more than 0·5 millim. in length.

The merus of the external maxilliped has its antero-external angle produced, and its inner border indented by two notches. The inner border of the ischium of the same appendage is serrated.

Chelipeds are smooth beneath the hairs. In this adult male they are a little stouter than the walking legs and 1·2 times as long as the carapace (excluding rostral spines). The fingers gape proximally for about two-thirds of their length, a tooth on the proximal portion of the mobile finger projecting into the hiatus. The distal, apposable portion of the fingers is denticulate.

Walking legs are smooth beneath the hairs. W.L.1.l. ÷ C.l. = 1·74 ; W.L.2.l. ÷ C.l. = 1·17 ; W.L.3.l. ÷ C.l. = 1·00 ; W.L.4.l. ÷ C.l. = 0·91. The dactylopodite of walking leg 1 is almost straight, denticulate, and about half as long as the propodite. The dactylopodites of walking legs 2, 3, and 4 are curved, spinulous, and about the same length as the propodites of the same appendages.

C.l.	C.b. ÷ C.l.	Ch.l. ÷ C.l.	Propus l. ÷ C.l.	Arm l. ÷ C.l.	H.l. (up. bord.) ÷ C.l.	F.l. (up. bord.) ÷ C.l.
11·5	0·78	1·20	0·59	0·52	0·33	0·22

Arm length is measured along under surface from proximal end of ischium to tip of outer distal tubercle. Ch.l. = sum of arm l. and a line uniting outer distal tubercle of arm to tip of fixed finger when elbow is bent at a right angle. Propus l. is measured along lower border by a straight line uniting the proximal tubercle to the tip of the fixed finger.

Remarks.—This species may be recognised by the character of its orbital border.

The bilobed character of its supra-ocular eave is a point of resemblance to *Halimus verrucosipes* and *Halimus gracilirostris.*

The denticle on the anterior border of the post-ocular tooth is referred to under *H. irami*, n. sp.

Halimus irami, n. sp.—Plate I., figs. 4, 4*a*.

Locality :—Muttuvaratu Paar, two specimens—an ovigerous ♀ (*a*) and a *Sacculina*-infested male (*b*).

Description of Ovigerous Female.—Body and legs tomentose. Carapace subpyriform ; the regions are defined, not very distinctly, by shallow grooves ; the grooves defining the hepatic region are well marked ; the gastric region shows a fairly prominent convexity. The denuded carapace is seen to be pitted, the pits well apart. The only protuberance on the carapace is a small epibranchial tubercle near the hinder limit of either branchial region. The rostral spines are 0·50 the length of the carapace (0·60 in the male example), fringed with a row of hairs on either side ; the distance between their tips is 0·90 the length of one of them ; though sloping obliquely downward, their slope is less inclined than that of the anterior surface of the carapace (in the male their slope is more oblique, in the same plane as that of the carapace).

The supra-ocular eave is produced anteriorly into a strong triangular tooth ; at the base of the post-orbital tooth, between it and the supra-ocular eave, is a small tooth (it varies in position in the two specimens, as will be remarked later).

The antennal flagellum consists of about eight elongated segments, from the joints between which arise a few isolated stout hairs ; it is damaged in this specimen, in the male it just falls short anteriorly of the tip of the rostral spine.

The outer anterior angle of the basal antennal segment is produced anteriorly into a stout tooth, visible from dorsal view, the outer border is a little convex ; to the outer side of the aperture of the green gland is a compressed tubercle ; behind the latter the

antero-external angle of the buccal cavern is produced as a petaloid projection; on the pterygostomial ridge running obliquely backward from this there are two tubercles, and a third still further back just above the base of the cheliped.

The chelipeds are rather more slender than the walking legs. Ch.l. ÷ C.l. = 0·91. The dactylopodites of the walking legs are roughened, hardly denticulate, on their lower borders. Carapace length is 8·75.

The general form of the carapace and of the rostral spines, together with the slight epibranchial tubercle, suggest alliance with the *H. convexus* group. The small but distinct supra-ocular tooth is interesting. It occurs in *H. agassizi*; in *H. pehleri* there is no isolated tooth, but the lower half of the upper anterior border of the large post-ocular tooth bears a smaller tooth, which is perhaps its representative. At all events, the two examples of *H. irami* enable one to make a very pretty series; in specimen (*a*) there is on the right an isolated supra-orbital tooth well separated from both supra-ocular eave and large post-ocular tooth, on the left side it is at the base of the latter, though distinct from it, in (*b*) it is on either side hardly separated from the post-ocular tooth and might be described as situated upon it: this leads to the condition seen in *H. pehleri*.

For purposes of key this new species comes under section II.2.ii.*b*. of ALCOCK'S arrangement (A.1, p. 208) with *H. planasius*; from the latter it is easily to be distinguished by its supra-ocular tooth.

The male example of the new species is of interest as exhibiting a condition of abdomen and chelipeds evidently due to the presence of the parasitic *Sacculina*. The chelipeds are much as in the female, the abdomen is much broadened, resembling that of a half-grown female; the larger pair of copulatory appendages reach back about half way along the abdomen.

Naxia investigatoris, ALCOCK, 1895—A.1, p. 218; A.Invest., pl. xxi., fig. 6.

Localities:—Coral reefs, Gulf of Manaar, one specimen (ovigerous ♀); pearl banks, Gulf of Manaar, one specimen (ovigerous ♀); off Mutwal Island, one specimen (♂).

Description:—	C.l.	Rost.sp.l. ÷ C.l.	Ch.l. ÷ C.l.
(*a*) ovigerous ♀ . . .	16·00	0·25	1·00
(*c*) adult ♂	16·00	0·37	1·19

The present male example suggests that facultative dimorphism occurs in the species. It has a well-grown appearance. In spite of its "non-breeding" type of cheliped, it is larger than a male specimen of ALCOCK'S in the British Museum, which has chelipeds of "breeding" type; it is perhaps a "middle" male.

Naxia hirta (A. MILNE-EDWARDS), 1865—A.1, p. 218.

Localities:—Aripu coral reefs, Gulf of Manaar, nine specimens; Chilaw Paar, one specimen; pearl banks, Gulf of Manaar, seven specimens; off Mutwal Island, two specimens.

Description:—	C.l.	Rost.spine l. ÷ C.l.	Ch.l. ÷ C.l.
(*a*) adult ♂	35·50	0·30	1·31
(*b*) ovigerous ♀ . . .	31·25	0·24	0·94
(*c*) adult ♂	18·25	0·22	0·88

In adult male (*a*) one notes: (1) The cheliped length exceeds considerably the length of the carapace, whereas ALCOCK describes his specimens as having these measurements equal; (2) the fingers are considerably arched and so are well separated at the base when clenched—again contrasting with ALCOCK's description. ALCOCK does not give the size of his specimens, they are evidently either young or "non-breeding" forms. In the present collection males agreeing with ALCOCK's description in characters of cheliped have C.l. from 18·00 to 21·00.

Doclea gracilipes, STIMPSON, 1857—A.1, p. 229.

Localities:—Trincomalee, three specimens; pearl banks, Gulf of Manaar, two specimens.

Description:—All the examples are young—three are males and two females. They fall under ALCOCK's general description of the species, and are in fairly close agreement with the *Doclea* sp. of DE MAN, from Mergui. The smaller of his two specimens I have seen in the British Museum.

Doclea alcocki, n. sp.—Plate I., fig. 5, Plate II., fig. 2.

Locality:—Pearl banks, Gulf of Manaar, one specimen.

Description:—A female, non-ovigerous, but, judging from the broad abdomen, it is adult. C.l. (a straight line uniting base of posterior spine to posterior end of rostral groove) = 44·5. Body and legs, except the hands and dactylopodites, are covered with velvet.

Carapace sub-pyriform rather than sub-globular (Pl. II., fig. 2); the posterior part of the margin is semicircular, the anterior part (rostrum included) is triangular. Rostrum bifid; its length (a straight line uniting the tip of a rostral spine to the posterior end of the longitudinal dorsal rostral groove) is 0·25 the carapace length; the length of the free portion of a rostral spine is 0·55 the rostrum length; the rostral spines are compressed in an oblique plane and curve a little downwards distally. Inter-orbital breadth (a straight line uniting the fissures between the supra-ocular eave and post-ocular tooth of either side) is 0·25 the carapace length. The anterior angle of the supra-orbital eave is produced obliquely forward and outward as a tubercle. There are numerous tubercles (say 56). Of these, eight are in the median longitudinal line and increase in size from before backwards (four gastric, of which the most anterior is about one-third the size of the other three, one between gastric and cardiac region, one cardiac, one on posterior border; the last named is a good deal larger than any of the others (at its base on either side is a smaller tubercle, that on the right quite minute, that on the left strongly developed). Just anterior to this median dorsal row is a pair of small tubercles, one

on either side of the posterior limit of the median longitudinal rostral groove; these and the small anterior one of the median dorsal row form a triangle; the three are sub-equal in size and are roughly one-third the size of the second member of the median dorsal row. The antero-external angle of the buccal cavern is produced into a tubercle, and this is the most anterior member of a row of four, of which the second is on the sub-hepatic region and the third and fourth are on the lateral border of the carapace. Parallel to this a row of four tubercles runs obliquely backwards and outwards from the posterior angle of the orbit; of these, the first is hepatic and the rest branchial. On either side between this row and the mid-dorsal row are twelve tubercles, four gastric and eight branchial. The gastric ones are small and occupy the corners of an antero-posterior oblong, of the branchial ones five follow the groove separating branchial from middle regions (second and sixth well developed, rest small), the remaining three lie to outer side, the posterior one being well developed, and the two anterior very close together. The middle regions of the carapace are separated from the lateral ones by distinct sinuous grooves; the branchio-hepatic groove also is distinct. In addition to the tubercles described above, the basal antennal segment is produced into one, there is another just behind this to the outer side of the opening of the green gland and just in front of the tubercle at the antero-external angle of the buccal cavern, already described. The interantennulary septum is produced ventrally in the middle region to form a much compressed tooth.

The merus of the external maxilliped has a very distinct notch in the anterior part of its inner border, its anterior border is oblique and a little convex, its outer angle rounded and slightly produced, its exposed surface concave; the ischium has its inner border obviously dentate. The length of the buccal cavern (a straight line uniting the inner base of the antero-external tubercle to the outer posterior angle) is 0·98, its breadth (across region of the two antero-external tubercles); outer border of merus ÷ breadth of buccal cavern = 0·48; outer border of ischium ÷ breadth of buccal cavern = 0·60.

Chelipeds slender, about the same degree of stoutness as the 2nd pair of walking legs, but a good deal shorter. Ch.l. ÷ C.l. = 1·15. W.L.1.l. ÷ C.l. = 2·37; W.L.2.l. ÷ C.l. = 1·98; W.L.3.l. ÷ C.l. = 1·64; W.L.4.l. ÷ C.l. = 1·37.

Abdominal segments IV. to VI. are fused (the specimen is female), but grooves representing joints remain very distinct.

Egeria arachnoides (RUMPHIUS)—A.1, p. 223.

Localities:—Coral reefs, Gulf of Manaar, one specimen; south-east of Ceylon, 18 fathoms, one specimen.

Description:—Males—both probably immature.

Tylocarcinus styx (HERBST), 1803—A.1, p. 235.

Locality:—Cheval Paar, two specimens (ovigerous ♀ and young ♀).

Description:—C.l. of the ovigerous female = 16·5.

Paramithrax (Chlorinoides) longispinus (DE HAAN), var. **bispinosus**, nov.

Localities:—Pearl banks, two specimens; coral reefs, Gulf of Manaar, three specimens; off Kaltura, one specimen; Trincomalee, one specimen; south-east of Ceylon, 18 fathoms, one specimen; deep water, off Galle, two specimens.

Description:—C.l. of an ovigerous female = 12·00 (posterior and rostral spines excluded). For characters of the species see A.1, p. 242.

The examples include two ovigerous females, one adult non-ovigerous female, five adult males, one doubtfully adult male, and one young male.

They all differ from DE HAAN's figure ("F. Japon. Cr.," pl. xxiii., fig. 2) in the absence of the most anterior of the three supra-ocular spines. I name them var. *bispinosus*. The "Challenger" specimens included by MIERS under *Paramithrax coppingeri* illustrate a parallel variation in that closely allied species; the *P. coppingeri* specimens of HASWELL have three supra-ocular spines—the "Challenger" examples have two only.

Schizophrys aspera (H. MILNE-EDWARDS, 1834)—A.1, p. 243, pl. xxxv., fig. 1.

Localities:—Off Mutwal Island, two specimens (young ♀ and adult ♂); Jokkenpiddi Paar, one specimen (young ♂); pearl banks, one specimen (young ♂); coral reefs, Gulf of Manaar, one specimen (young ♀).

Description:—C.l. of the adult male = 29.

Cyclax suborbicularis (STIMPSON), 1857—A.1, p. 245.

Locality:—Galle, lagoon, one specimen.

Description:—A young male. It agrees in many points with A. MILNE-EDWARDS' fig. 2 of a young form ('Nouv. Archiv. du Mus.,' viii., p. 236, pl. x., 1872). The orbit, however, is different from his figures, both of young and adult, but as growth-changes are very considerable in this species, I do not exclude my specimen from it.

Stenocionops cervicornis (HERBST), 1803—A.1, p. 248.

Localities:—Jokkenpiddi Paar, one specimen (*b*); Cheval Paar, two specimens (*a*, *c*); pearl banks, Gulf of Manaar, three specimens; Chilaw Paar, three specimens; coral reefs, Gulf of Manaar, four specimens.

Description:—Among the specimens is one ovigerous female, one adult non-ovigerous female, and at least one adult male.

	C.l.	C.b. ÷ C.l.	Rost.spine ÷ C.l.	Sup.-oc.spine ÷ C.l.	Eye stalk ÷ C.l.
(*a*) ovigerous ♀ . . .	34·50	—	0·42	0·41	0·34
(*b*) adult ♀	25·00	0·71	0·35	0·37	0·34
(*c*) adult ♂	42·00	—	—	—	—

The posterior projection is, in all the specimens, blunter and more broadly triangular than in CUVIER's figure in the "Règne Animal" (pl. xxxi., fig. 1), *i.e.*, it is to some

extent intermediate between that figure and A. MILNE-EDWARDS' figure of *Stenocionops curvirostris.* Among the present specimens there is nothing further to minimise the somewhat slender specific distinction between *S. cervicornis* and *S. curvirostris.*

In the young examples the tuberculation is less distinct than in the adult, and also the posterior projection of the carapace is less prominent. HENDERSON (p. 343) found in his specimens that the posterior projection was narrower and more upturned in the male than in the female; this does not hold as a distinction between the ovigerous female and the adult male of the present collection.

It would be of interest to re-examine A. MILNE-EDWARDS' "type"-specimens of *Stilbognathus* for the purpose of verifying the generic distinction between that genus and *Stenocionops.*

Pseudomicippa nodosa, HELLER, 1861—'S.B. Ak. Wien,' xliii., p. 303, pl. i., fig. 3.

Locality: —Muttuvaratu Paar, Gulf of Manaar, one specimen.

Description:—An ovigerous female. C.l. (without front) = 9·50. It is labelled "crab with black sponge." The sponge completely covers the dorsum of the carapace.

Remarks.—For remarks on the limits and affinities of the genus, see CALMAN (p. 40). He favours the generic separation of *P. nodosa* and *P. varians* on the grounds that (1) the rostrum is very strongly deflexed in *P. nodosa*—not so in *P. varians*; (2) the anterior angle of the orbit is produced into a long spine in *P. nodosa*—not so in *P. varians*; (3) the distal tooth of the basal antennal joint is directed obliquely forwards in *P. nodosa*—outwards in *P. varians.* With the additional evidence of the present specimen and of some specimens in the British Museum, I find it inadvisable to separate the species generically. Thus the present example combines the strongly deflexed rostrum of *P. nodosa* with an anterior orbital angle which is only drawn out a little more than in *P. varians.* In the British Museum I find specimens which show some variation in the degree to which the rostrum is deflexed. The third distinction does not appear to me to be one of generic value. In the present specimen the antennal angle is *nodosa*-like in pointing obliquely forwards, though it differs from HELLER'S figure—the latter agreeing with dried Red Sea specimens in the British Museum. This genus is new to the Indian fauna.

Micippa philyra (HERBST), 1803—A.1, p. 249.

Localities:—Coral reefs, Gulf of Manaar, four specimens (*a*, *b*, *d*, *e*); off Mutwal Island, one specimen (*c*).

Description:—

	C.l.	C.b. ÷ C.l.	Antenn.l. ÷ C.l.	2nd sgt.ant.l. ÷ R.b.	Arm.l. ÷ C.l.	H.l. ÷ C.l.	H.b. ÷ H.l.
(*a*) ovig. ♀.	23·00	0·87	0·43	0·25	0·33	0·24	0·36
(*b*) adult ♂.	20·00	0·87	0·50	0·34	0·39	0·35	0·61
(*c*) adult ♂.	22·50	0·87	0·51	0·28	0·37	0·29	0·46

ALCOCK records a male dimorphism in this species, believing it to be comparable

with the phenomenon recorded among the beetles. Dimorphism is illustrated by the males (*b*) and (*c*) above, but it is noteworthy that it is the larger example (*c*) which has the more female-like form of cheliped, while the smaller one (*b*) has a cheliped of strongly marked male character. This seems to be a case of facultative dimorphism, specimens (*b*) and (*c*) being respectively "breeding" (perhaps "low") and "non-breeding" ("middle") forms.

In length of mobile portion of the antenna, the two adult males come under var. *mascarena*. In the ovigerous female this measurement is larger than in females of the species as described by ALCOCK.

The surface of the post-cardiac region of the carapace varies in character. It is smooth in (*b*), it has a trace of granulation in (*a*) which is rather more obvious in (*c*) and (*d*) and quite fairly developed in (*e*). The vertical portion of the carapace plus the rostrum has in (*a*) and (*b*) a flattened surface, in (*c*) the lateral pair of lobes curve forward somewhat, so that the anterior surface is concave from side to side. Example (*d*) is intermediate.

All the specimens possess the following spines on the lateral margins of the carapace:—Three spines on hepatic border, one (a small tubercle) on the antero-lateral branchial border, three on branchial border in the region of the epibranchial angle. In addition, the two males (*b*) and (*c*) have two spines, both obsolescent in (*c*), and anterior one so in (*b*), on the border between the epibranchial angle and the true posterior margin of the carapace, just above the granular ridge.

Micippa thalia (HERBST), 1803—A.1, p. 251.

Localities:—Off Mutwal Island, two specimens; coral reefs, Gulf of Manaar, seven specimens; Cheval Paar, two specimens; pearl banks, Gulf of Manaar, 18 specimens.

Description:—The specimens fall into two groups, corresponding with the figures of A. MILNE-EDWARDS ('Nouv. Archiv. du. Mus.,' viii., p. 238, pl. xi., fig. 1, 1872) and of HERBST ('Krabben,' iii., pl. lviii., 3) respectively. Twenty-eight of them agree very fairly with the former and one with the latter. It may be noted that forms resembling the "type"-specimen of this species have been seldom recorded.

A. The following is the arrangement of the spines in 20 adult individuals of the first variety. The number which occurs in each region with maximum frequency is printed in heavy type.

Dorsal Surface of Supra-ocular Hood.—Fourteen specimens have a mere indication of one granule on each hood, three have a more obvious granule, and three have a small blunt spinule.

Dorsal Surface of Branchial Region.—Nineteen specimens have two spines on each side (may be written **2·2**), one specimen has one on the left side and two on the right side (may be written 1·2).

Gastric Region.—Nineteen specimens have **2** median spines (reduced in one specimen), and one has a spine and a granule.

Upper Margin of the Orbit behind the Supra-ocular Spine.—All have **3·3**, of which the third is the largest.

Hepatic Margin.—All have **3·3**.

Branchial Margin.—Fifteen specimens have **5·5**; one has 4·5; one has 5·6; one has 5·7; one has 6·6; one has 6·7.

B. Specimen (*a*), an ovigerous female, differs from the other examples in the collection in various ways, as set forth below, and goes with HERBST'S "type"-specimen of the species:—

(1) The rostral spines are more strongly curved outwards at their tips (see HERBST'S figure).

(2) The hepatic regions are not so much pinched in dorsally.

(3) The under surface of the basal antennal segment is smooth and its antero-lateral angle is produced into a longer, more definite spine, the border of which is entire (in the A-specimens the outer half of the under surface of the basal antennal segment is more or less granular, and its antero-lateral angle is produced to form a triangular and less spiniform infra-orbital projection with a crenulate border).

(4) The arrangement of spines is different.

Dorsal surface of the supra-ocular hood of either side has a definite blunt spine. The anterior and posterior angles of the eave form blunt projections.

Dorsal surface of branchial region of each side has three arranged in a longitudinal row; of each row the two anterior members are spinules merely, the posterior one is a well-developed spine. There is also a denticle on the branchial region which would lie about one-third way along a line drawn from the large spine just named to the middle point of the gastro-cardiac groove.

Gastric Region.—Two not very obvious median tubercles.

Upper margin of orbit behind the supra-ocular eave of either side has three spines, the middle one much the strongest.

Hepatic Margin, 0.

Branchial Margin, 7 8 (on the left side the anterior four are granules, the three posterior are larger; on the right side the anterior five and the seventh are granules; the sixth and eighth are larger).

Posterior Border of Carapace.—A pair of spines close together, one on either side of middle point.

Of the above particulars the form of the rostral lobes, the strong development of the middle one of the three supra-orbital spines, the presence of the two spines of the posterior border, and the crenulate margin of the antero-lateral spiniform production of the basal antennal segment, are conveniently conspicuous characters.

Micippa margaritifera, HENDERSON, 1893—A.1, p. 253; A. Invest., pl. xxxv., fig. 3.

Localities:—Jokkenpiddi Paar, two specimens (ovigerous ♀); Aripu coral reef, one

specimen (ovigerous ♀); Gulf of Manaar, three specimens (one adult ♂ and two young ♂).

Description:—All the specimens have their walking legs folded beneath them, in which position the expanded meropodites, together with the retroflected tip of the rostrum, enclose a space beneath the body and help to give the animal a rounded ball-like appearance. The space referred to is widely open posteriorly, where a considerable squarish gap is left between the members of the last pair of walking legs. Slits remaining between the successive legs of either side are more or less occluded by fringes of hair which border the appendages.

A variable character to note is the size of the innermost of the three branchial tubercles; in none of the specimens, however, does this exceed two-thirds of the size of the two outer tubercles.

Micippa parca, Alcock, 1895—A.1, p. 253; A.Invest., pl. xxxv., fig. 4.

Locality:—Coral reefs, Gulf of Manaar, one specimen.

Description:—C.l. = 11·25 (a straight line uniting base of the median posterior spinule with the middle point of a faint inter-ocular groove); C.b. ÷ C.l. = 0·98; Inter-orbital b. ÷ C.l. = 0·58 (inter-orbital breadth is measured by a straight line uniting the notches made by the junction of pre-ocular spinule with supra-ocular eave of either side); breadth between the bases of the mobile portions of the antennæ ÷ C.l. = 0·36; Arm l. ÷ C.l. = 0·42; H.l. ÷ C.l. = 0·38.

The present specimen of *M. parca* differs from *Micippa margaritifera*, to which it is closely allied, in the following particulars:—

(1) The median region of the posterior border of the carapace is occupied by a group of spinules (three in a transverse row) instead of by a single pearl-like tubercle; (2) the post-cardiac cluster of granules and the cluster on either side of it are but slightly indicated; (3) the gastro-cardiac groove is more distinct; (4) the difference in size between the inner branchial spinule (a mere rudiment—not a real spinule) and the two outer ones (well developed) is more marked; (5) the meropodites of the walking legs are still more expanded, which is largely due to the greater foliation of their posterior borders; their distal borders are finely and fairly regularly toothed; (6) the walking legs are less hairy; (7) the upper portion of the outer surface of the hand is granular.

Lambrus (Lambrus) longimanus, Leach, 1815—A.1, p. 260.

Localities:—Galle, three specimens (*c*, *e*, *g*); pearl banks, Gulf of Manaar, four specimens (*a*, *b*, *d*, *f*).

Description:—	(*a*) young ♀.	(*b*) young ♀.	(*c*) young ♂.	(*d*) young ♂.	(*e*) young ♂.	(*f*) adult ♂.
C.l. (rost. included)	11·50	17·50	9·75	12·00	17·50	25·50
C.b. ÷ C.l. . . .	1·04	1·01	1·50	1·00	1·11	1·12
Ch.l. ÷ C.l. . . .	3·22	3·31	3·10	3·25	3·64	4·40

In the young male (*e*) the median lobe of the rostrum is reduced to a declivous denticle of approximately the same length as the denticular lateral lobes, which are in this example more strongly developed than usual. Considerable growth-changes in cheliped length for males are indicated by the measurements given above.

Lambrus (Platylambrus) carinatus, H. M.-Edw., 1834—A.1, p. 263.

Localities:—Coral reefs, Gulf of Manaar, four specimens; off Mutwal Island, one specimen; pearl banks, Gulf of Manaar, nine specimens.

Description:—The specimens include four ovigerous females (incl. *f–h*), six non-ovigerous females (incl. *a–e*), and four adult males.

	(*a*) ♀.	(*b*) ♀.	(*c*) ♀.	(*d*) ♀.	(*e*) ♀.	(*f*) ♀.	(*g*) ♀.	(*h*) ♀.	(*i*) ♂.	(*j*) ♂.	(*k*) ♂.	(*l*) ♂.
C.l. . . .	8·75	11·00	11·25	13·00	13·00	9·25	11·25	11·50	9·25	9·25	11·25	11·25
Arm.l. ÷ C.l.	0·80	0·77	0·82	0·65	0·73	0·73	0·73	0·72	0·89	0·86	0·84	1·02
H.l. ÷ C.l. .	0·94	0·93	1·02	0·83	0·92	0·94	0·87	0·83	0·94	0·95	0·96	1·11

Some characters exhibit high variability:—

(1) The mid-dorsal teeth may be large and laterally compressed, or they may be smaller and peg-like. In one example the most anterior of the three is obsolescent.

(2) The branchial ridges vary in number and in character. There may be on each side a single sharp carina, a single granular ridge, a pair of granular ridges, or a pair of smooth ridges; the second ridge may be very inconspicuous, and there may be a granule or two in the middle of such a faint ridge.

(3) The carapace may be free from granules, or granules may be present, but confined to the depression on either side of the cardiac region, or a few may extend over the branchial region also.

Remarks.—I include *Lambrus holdsworthi*, Miers, as a synonym. A. Milne-Edwards' brief diagnosis of *L. carinatus* applies to Miers' "type"-specimens of *L. holdsworthi* in the British Museum. Some of my specimens, which I group as var. *holdsworthi*, agree with the latter; others agree with Alcock's description of his examples of *L. carinatus*—I call these var. *alcocki*.

In var. *alcocki* there is a single carinate ridge on each branchial region; in var. *holdsworthi* there are two low granular ridges.

In var. *alcocki* the mid-dorsal tubercles are more prominent and are laterally compressed; in var. *holdsworthi* they are more peg-like and less prominent.

In var. *alcocki* the carapace tends to be free from granules; a fair number of granules are present in var. *holdsworthi*.

The variations presented by the present forms in regard to median dorsal teeth and branchial ridges—which I have referred to above—minimise or break down two of the distinctions which Alcock draws between his specimens of *L. carinatus* and of *L. prensor*. All my specimens agree with those described by Alcock in the character of the sub-orbital lobe (bilobed, the inner lobe rounded and not produced

into spine nor seen in dorsal view) and of the anterior borders of the meropodites of the walking legs (serrate).

Lambrus (Rhinolambrus) contrarius (HERBST), 1804—A.1, p. 266.

Localities:—Coral reefs, Gulf of Manaar, four specimens (*b*, *c*, *g*, *h*); pearl banks, Gulf of Manaar, four specimens (*a*, *e*, *i*, *d*); Chilaw Paar, one specimen (*f*).

Description:—	(*a*) yg. ♀.	(*b*) yg ♀.	(*c*) yg. ♂.	(*d*) yg. ♂.	(*e*) yg. ♂.	(*f*) yg. ♂.	(*g*) ad. ♂.
C.l. (rost. included) .	11·50	24·00	9·50	18·00	19·75	22·75	38·75
C.b. ÷ C.l.	0·89	0·92	0·84	0·92	0·90	0·89	0·93
Ch.l. ÷ C.l.	2·17	2·30	2·18	2·36	2·34	2·58	2·86

The growth-changes in ratio Ch.l. ÷ C.l. will be noted.

Lambrus (Rhinolambrus) longispinis, MIERS, 1879—A.1, p. 266.

Localities:—Pearl banks, Gulf of Manaar, eight specimens; coral reefs, Gulf of Manaar, three specimens.

Description:—The specimens are all young—four of them males. The C.l. of the latter varies from 10·5 to 16; the scanty evidence suggests that no great change in the ratio Ch.l. ÷ C.l. accompanies this growth. There is at this size no very obvious establishment of sexual dimorphism.

	(*a*) yg. ♀.	(*b*) yg. ♀.	(*c*) yg. ♀.	(*d*) yg. ♀.	(*e*) yg. ♂.	(*f*) yg. ♂.	(*g*) yg. ♂.	(*h*) yg. ♂.
C.l. (rost. included) .	12·25	12·25	12·50	19·25	10·50	11·25	12·50	16·00
C.b. ÷ C.l.	0·94	0·98	0·92	1·00	0·98	0·94	0·92	0·97
Ch.l. ÷ C.l. . . .	2·14	2·16	2·06	2·39	2·24	2·11	2·08	2·22

The present specimens agree closely with ALCOCK'S example and confirm his belief that the species is more nearly related to *L. contrarius*, HERBST, than to *L. validus*, DE HAAN. Variability is low among the above examples for most characters; the shape of the rostrum is an exception. The latter is acutely pointed in most of the examples, narrowing rather suddenly a short distance in front of the eyes; in one specimen no such sudden narrowing occurs; in another there are two small lateral lobes near the apex; other examples are intermediate.

Lambrus (Rhinolambrus) pelagicus, RÜPPELL, 1830—A.1, p. 267.

Localities:—Coral reefs, Gulf of Manaar, one specimen (young ♀); off Mutwal Island, one specimen (adult ♂).

Description:—

Young ♀ . . . . C.l. = 7·50; C.b. ÷ C.l. = 1·00; Ch.l. ÷ C.l. = 2·63.
Adult ♂ . . . . C.l. = 16·00; C.b. ÷ C.l. = 1·02; Ch.l. ÷ C.l. = 3·16.

Lambrus (Aulacolambrus) hoplonotus, ADAMS and WHITE, 1848—A.1, p. 273.

Localities:—Pearl banks, Gulf of Manaar, four specimens (*a*, *b*, *e*, *g*); coral reefs, Gulf of Manaar, three specimens (*c*, *d*, *f*).

Description :—	(*a*) young ♀.	(*b*) young ♀.	(*c*) adult ♀.	(*d*) young ♂.	(*e*) young ♂.	(*f*) adult ♂.
C.l. . . .	7·00	13·00	15·00	8·50	9·25	13·25
Ch.l. ÷ C.l. .	2·75	2·62	2·77	2·71	2·65	2·57

The above series present but little variation among themselves. They come under var. *planifrons*, with some approach also to var. *granulosus*. Thus adult female (*c*) bears considerable resemblance to MIERS' specimen of var. *planifrons* in the British Museum, excepting that the spines of the posterior border of the hand are neither so flattened nor so broad, *i.e.*, more as in var. *granulosus*, and in the same example the apex of the rostrum is a further point of resemblance to the latter variety.

The number of spines on the outer border of the hand is fairly constant, that of the teeth of the inner border more variable. Thus in all the specimens there are on the outer border of the hand six large smooth spines and four smaller alternating ones (the most distal of the alternating spines is in (*b*) larger than in the others, and in (*f*) it is almost the size of the larger ones); the inner border bears from eleven to thirteen teeth.

Lambrus (Aulacolambrus) curvispinis, MIERS, 1879—A.1, p. 274.

Localities :—Galle, one specimen (adult ♀); Trincomalee, one specimen (ovigerous ♀).

Description :— Adult ♀ . . . . . . C.l. = 21·00; Ch.l. ÷ C.l. = 3·07.
Ovigerous ♀ . . . . C.l. = 24·00; Ch.l. ÷ C.l. = 3·15.

Lambrus (Parthenolambrus) calappoides (ADAMS and WHITE), 1847—A.1, p. 275.

Localities :—Coral reefs, Gulf of Manaar, nine specimens (*a* to *i*); Trincomalee, one specimen (*j*).

Description :—

	(*a*) yg. ♀.	(*b*) yg. ♀.	(*c*) yg. ♀.	(*d*) ad. ♀.	(*e*) ♂.	(*h*) ♀.	(*i*) ♀.	(*f*) ♂.	(*g*) ♂.	(*j*) ♂.
C.l. . . .	9·50	14·50	15·75	19·25	19·00	14·50	17·50	8·00	14·00	16·75
Ch.l. ÷ C.l. .	1·84	1·84	—	—	2·09	1·66	1·71	1·97	1·96	2·04

The present examples show a good deal of variation about two centres; the two groups I call var. *alcocki* (corresponding more or less with ALCOCK'S description of *L. calappoides*) and var. *confragosus* (= *L. confragosus*, CALMAN).

I have seen the "type"-specimens of *L. confragosus* in the British Museum, and find that with the aid of the present forms and of the British Museum examples of *L. calappoides* I can arrange a transitional series which unites the two forms named.

Differences between the two varieties are :—(1) The post-ocular notch is well indicated in var. *confragosus*; absent in var. *calappoides*. (2) The lateral hepatic region is prominent, dentiform and compressed in var. *confragosus*; little prominent and rounded in var. *calappoides*. (3) The post-hepatic notch is well indicated in var. *confragosus*; slightly so in var. *calappoides*. (4) The median dorsal spines are prominent and pointed backward in var. *confragosus*; in var. *calappoides* they are represented by inconspicuous tubercles. (5) The tubercles of the carapace are

granulated in var. *confragosus*; in var. *calappoides* they are more or less smooth, low and obsolescent and the general surface of the carapace tends to be pitted and uneven, producing what ALCOCK aptly terms a "boiled" appearance. (6) The postero-lateral angles are angular and spine-bearing in var. *confragosus*; rounded in var. *calappoides*. (7) The greatest carapace-breadth is in var. *confragosus*, across the region of the postero-lateral angle; in var. *calappoides* it is anterior to this region. (8) There are two large tubercles on the inner border of the arm in var. *confragosus*, one about one-third from its distal end and the other about one-third from its proximal end. The latter is the larger, a good deal compressed from above downwards, and has a small tubercle at its base; in var. *calappoides* there are traces only of both. (9) The rostrum is obliquely deflexed in var. *confragosus*; vertically deflexed in var. *calappoides*.

The above characters show a fair degree of correlation; the transitional forms tend to combine intermediate conditions of most of them. The correlation is, however, by no means perfect, *e.g.*, a "Challenger" female from "off Tongatabu," in the British Museum, combines with most characters of var. *calappoides* a considerable development of the median dorsal spines.

Lambrus (Parthenolambrus) beaumonti, ALCOCK, 1895—A.1, p. 276.

Localities:—Coral reefs, Gulf of Manaar, three specimens (*a*, *d*, *e*); south of Galle, deep water, one specimen (*b*); Gulf of Manaar, deep water, one specimen (*c*).

Description:—	(*a*) young ♀.	(*b*) ovigerous ♀.	(*c*) ovigerous ♀.	(*d*) adult ♂.	(*e*) adult ♂.
C.l.	6·75	7·75	8·00	9·25	10·00
C.b. ÷ C.l. . . .	1·11	1·06	1·09	1·00	1·07
Ch.l. ÷ C.l. . . .	1·74	—	1·91	2·46	2·90

The difference in ratio Ch.l. ÷ C.l. between the two males—both apparently adult—is interesting. In the present forms there is much variation in the size of gastric and cardiac tubercles. They are both absent in the young female example (*a*), they are both rudimentary in the larger of the two males (*e*), there is a blunt tubercle on each of these regions in ovigerous female (*b*), finally, in the smaller male (*d*), there is a stout spine on the gastric eminence, and a still stouter one on the cardiac.

Lambrus (Parthenolambrus) harpax, ADAMS and WHITE, 1848—A.1, p. 278.

Locality:—Pearl banks, one specimen.

Description:—A male, apparently young. C.l. = 14·25; Ch.l. ÷ C.l. = 2·79. This individual, belonging to a highly variable species, agrees with ALCOCK's description of the Indian Museum specimen from the Andamans, excepting that the index Ch.l. ÷ C.l. is considerably higher.

Cryptopodia fornicata (FABRICIUS), 1793—A.1, p. 282.

Locality:—Pearl banks, Gulf of Manaar, one specimen.

Description:—A young male, C.l. (rostrum included) = 18·0; C.b. ÷ C.l. = 1·46.

Cryptopodia pan, n. sp.—Plate I., fig. 6, and text-fig. 4.

Localities:—Coral reefs, Gulf of Manaar, one specimen (adult ♀ = *a*); west of Periya Paar, 17 to 24 fathoms, two specimens (young ♀ = *b*; young ♂ = *c*).

Description of female (*a*):—C.l. (rostrum included) = 22·5. Carapace broadly triangular; antero-lateral margin slightly sinuous, smooth in its anterior third and lacinated in its posterior two-thirds; the posterior and postero-lateral margins form a single strong curve, the edge of which shows faint traces of crenulation; the surface of the carapace is fairly smooth to the naked eye, but some obsolescent granules crown the prominences, and there are a few also scattered on the posterior slope; there are some

Fig. 4. *Cryptopodia pan*, n. sp.

pits, obvious to the naked eye, on the cardiac prominence and on the prominence on either side of it; the whole surface (as also that of the chelipeds) is dull, which is seen under lens to be due to a fine pitting which covers it; the triangular depression is shallow; the oblique branchial ridge of either side is much swollen and rounded; the rostrum is prominent, obtusely pointed, rather longer than broad, and has the anterior part of the edge faintly crenulate. The carapace is produced beyond the abdomen posteriorly for a distance equal to 0·08 the carapace length. C.b. ÷ C.l. = 1·43.

The third pair of maxillipeds form together a striking bulge. This is due in part to curvature of the appendage, but the most important factor is an actual thickening of the substance of the ischium. The exposed surface of the ischium is glazed, its outer two-thirds particularly are thickened, its inner one-third is ornamented with a double row of granules. The merus is granular on its proximal portion; distally it is smooth beneath a pubescence. The exopodite is, for the most part, concealed in ventral view by the ischial bulge.

The chelipeds are much as in *Cryptopodia fornicata* (see A.1, p. 282), but the surface is dull, not glazed; the armature is not so sharp; the outer border of the wrist has no tooth, but its blunt outer angle is well developed, so that its outer border is made up of two borders of approximately equal length set at right angles to each other. The meropodites of all the walking legs have their upper border, and those of

the 1st and 4th pairs their lower border also, armed with a spiniform crest; the other segments are a little compressed from side to side, but not carinate.

Differences from *Cryptopodia fornicata* are:—(1) The duller surface of the carapace and chelipeds (due largely to fine pitting); (2) the more rounded surfaces of the prominences, and less sharply cut armature; (3) the angular wrist; (4) form of rostrum; and (5) the swollen external maxillipeds. The last-named particular separates the new species at a glance from any other member of the genus known to me.

Heterocrypta petrosa, KLUNZINGER, 1906—(K., p. 53, pl. ii., figs. 9*a*, *b*).

Locality:—Gulf of Manaar, one specimen (*a*); off Mutwal Island, one specimen (*b*).

Description:—	C.l.	C.b. ÷ C.l.	Ch.l. ÷ C.l.	Rt.H.b. ÷ Lt.H.b.
(*a*) Ovigerous ♀ . . .	13·25	1·47	2·00	1·50
(*b*) Adult ♂	18·00	1·57	2·44	1·35

In the female specimen the true posterior border of the carapace forms a convex bulge. The carapace regions are more rounded in the male specimen than in the female. The latter variation is probably not concerned with sex, for KLUNZINGER'S figure of a male bears a stronger resemblance to my female than to my male example in this respect.

Remarks.—This species falls decidedly into the genus *Heterocrypta*, as defined by ALCOCK, but, having conformed so far, its further resemblances are rather to *Cryptopodia spatulifrons* than to any *Heterocrypta*. Such resemblances concern (1) general appearance of cheliped (no crest, however, on outer surface of wrist); (2) general shape of posterior border of the animal (*i.e.*, true posterior border of carapace together with posterior border of clypeiform expansions); (3) sculpture of exposed surface of the external maxillipeds, of uncovered portions of thoracic sterna, and of the abdominal terga.

On its part, *Cryptopodia spatulifrons* (as also *C. dorsalis*) makes some approach to *Heterocrypta* in the slight posterior expansion of its carapace—much slighter, for example, than in *Cryptopodia fornicata*.

Zebrida adamsi, WHITE, 1847—A.1, p. 287.

Localities:—Gulf of Manaar, one specimen; south of Manaar Island, two specimens.
Description:—C.l. of an adult male (rostral lobes included) = 8·0.

Harrovia albolineata, ADAMS & WHITE, 1848—('"Samarang" Zool.,' Crust., p. 56).

Localities:—South of Manaar Island, hauls 3, 4 and 5, two specimens (adult ♂, adult ♀); pearl banks, Gulf of Manaar, one specimen (young ♀); coral reefs, Gulf of Manaar, one specimen (ovigerous ♀).

Description:—C.l. of ovigerous female = 7·00.

CYCLOMETOPA.

Carpilodes tristis, DANA, 1852—A.3, p. 82.

Locality :—Galle, lagoon, three specimens (one adult ♂, two young ♂).

Description :—C.l. of adult male = 10·0.

Carpilodes pediger, ALCOCK, 1898—A.3, p. 83 ; A.Invest., pl. xxxvi., fig. 4, ♀.

Localities :—Off Mutwal Island, two specimens (one adult ♂ = *a*, one young ♂ = *b*) ; west of Periya Paar, 17 to 24 fathoms, one specimen (adult ♀ = *c*) ; pearl banks, Gulf of Manaar, three specimens (adult ♂ = *d*, ovigerous ♀ = *f*, young ♀ = *e*).

Description :—C.l. of ovigerous female = 5·25.

The third of the four antero-lateral teeth of the carapace may be continuous with the lobe 4L of DANA'S nomenclature as in (*b*), it may be separated therefrom by a faint groove as in (*a*), (*d*), and (*e*), or by a more evident groove, agreeing with ALCOCK'S figure, as in (*f*).

Carpilodes cariosus, ALCOCK, 1898—A.3, p. 86 ; A.Invest., pl. xxxvi., fig. 7, ♀.

Localities :—Muttuvaratu Paar, 6 to 9 fathoms, one specimen (adult ♂ = *a*) ; Gulf of Manaar, three specimens (young ♂ = *b*, two adult ♀ = *c*, *d*) ; Jokkenpiddi Paar, one specimen (adult ♀ = *e*).

Description :—C.l. of an adult female = 4·50.

There is variation in lobulation of carapace. The lobe 3M (DANA'S nomenclature) is entire in all except the young male (*d*), where a groove separates the narrow anterior limb from the posterior broad part. Lobe 2M is completely divided by a longitudinal groove in all except the adult female (*b*), in which the groove is incomplete posteriorly. The outer division of 2M is entire in adult females (*b*) and (*e*) ; its inner border is notched in adult male (*a*) on both right and left sides of the animal ; in adult female (*c*) its inner border is notched on the lobe of the right side of the animal, while on the lobe of the left side there is an indication of a transverse groove ; finally, in young male (*d*) a distinct transverse groove divides the lobe of each side. Lobe 5L is entire in all except adult male (*a*), in which it is divided obliquely. Lobes 2R, 1R, and S are fused in adult male (*a*) and adult females (*b*, *c*) ; in young male (*d*) and in adult female (*e*) there is an indication of their separation by grooves. Variation is not always bilaterally symmetrical. The degree of sub-division of the lobules is the most apparent difference between the present species and *C. monticulosus*. The variations above noted are within the limits allowed to the species by ALCOCK.

Atergatis integerrimus (LAMARCK), 1818—A.3, p. 95.

Locality :—Galle, lagoon, one specimen (very small young).

Lophactæa anaglypta (HELLER), 1861—A.3, p. 102.

Locality :—Gulf of Manaar, two specimens (both males). C.l. = 16·0.

(See RATHBUN, 'Proc. Biol. Soc. Wash.,' xi., p. 159, for *Platypodia* as generic name.)

Zozymus gemmula, DANA, var. **ceylonica,** nov.—Plate I., fig. 7.

Locality :—Trincomalee, three specimens (*a*, *b*, *c*).

Description :—Two males, one of which appears to be adult, and one female, which, though non-ovigerous, has a broad abdomen loosely applied to the sternum and may well be adult. Except in regard to the walking legs, the specimens show a very close similarity in most respects to those described and figured by DE MAN under *Zozymus gemmula*, DANA (DE MAN, 'Abh. Senck. Ges.,' xxv., p. 588). However, the walking legs show considerable differences. The following is a description of these appendages in my specimens :—The four pairs of the same individual are very similar. Dorsal border of the meropodite faintly denticulated. Carpopodite and propodite have well-developed dorsal crests ; that of the carpopodite is deeply fissured about the middle of its extent (a little more distal than the middle). The carpopodite has a longitudinal groove on its posterior surface ; a transverse groove crosses this, continuing the line of the incision of the crest, and marking off a more or less triangular distal area of the segment. The joint between carpopodite and propodite is markedly oblique. The lower border of the propodite curves upward obliquely, approaching the upper border, so that the segment is more or less triangular in shape. The upper part of the flattened posterior surface of the propodite presents a triangular excavation filled with hair. The dactylopodite is narrow and slightly curved, terminating in a dark brown spinule.

The points in which the walking legs differ from DE MAN'S description and figure of those of *Z. gemmula* concern : (*a*) the similarity of the members of the four pairs—in DE MAN'S specimens they show considerable differences ; (*b*) the upper border of the meropodites ; (*c*) the free edges of the dorsal crests of carpopodite and propodite form a continuous even line ; (*d*) the position of the fissure of the upper crest of the carpopodite ; (*e*) the transverse grooves of the posterior face of the carpopodite ; (*f*) the dorsal border of the propodite (for detail compare with DE MAN'S figure).

Further differences from DE MAN'S specimens are :—(1) The most posterior tubercle on the dorsal border of the hand is more prominent, it attracts notice with its flattened surface and its backwardly and inwardly projecting sharpened edge ; (2) the anterior border of the front is a little more horizontal (see figures)—DE MAN found that the front was more prominent in the male than in the female, this does not hold for my specimens ; (3) the ratio of fronto-orbital breadth divided by carapace length is greater in both sexes ; (4) the granules of the outer surface of the fixed finger are more definitely arranged in two longitudinal rows ; (5) they are smaller : it is possible, however, that they are not fully grown.

The value of distinctions (2), (3), and (4) appears to me very doubtful. I only

emphasise particularly (1) above, together with the condition of the walking legs, and for the present consider this form a variety of *Z. gemmula.*

I may note that 2M is completely divided into two by a longitudinal groove both in DE MAN'S *Z. gemmula* and in the new variety, while DANA describes it as only partly divided. Another point is that in the present specimens the hollowing of the finger tips is not obvious; I should describe the fingers as blunt merely, DE MAN'S figure indeed represents them very well. A point in the present specimens not mentioned by DE MAN is the presence of a curious little tuft of brown hair (seen well with a lens) which rises from a groove running along the inner surface of the fixed finger.

	(*a*) adult ♂.	(*b*) young ♂.	DE MAN'S ♂.	(*c*) adult ♀.	DE MAN'S ♀.
C.l.	7·25	5·50	14·25	6·25	10·00
C.b. ÷ C.l.	1·48	1·45	1·47	1·48	1·53
Fronto-orbital b. ÷ C.l.	0·93	1·00	0·81	1·00	0·90

Demania, n. gen.

Carapace pentagonal, moderately convex antero-posteriorly, flattened from side to side in its posterior half; the regions well delimited and subdivided into numerous lobules, the surface of which is smooth. The antero-lateral borders are blunt, cut by shallow grooves into four lobes: the border is faintly continued below the eye to the antero-lateral angle of the buccal cavern; the postero-lateral borders are straight and strongly convergent.

Front prominently bilobed, its breadth about one-third the greatest carapace-breadth, its plane is a continuance of the postero-anterior curve of the dorsum of the carapace. Orbits large, the three suture lines near the outer angles distinct; eyes on short thick stalks.

The antennules fold in a transversely oblique direction, making an angle of 40° (approximately) with a transverse line; the inter-antennulary septum is broad. Basal joint of antenna not quite as long as the posterior border of one of the antennulary fossæ; as a whole it stops short of the orbital hiatus, but its antero-external angle is produced into the latter; its antero-internal angle touches a downward projection of the front; the flagellum is short (less than major diameter of orbit), lodged in the orbital hiatus.

No ridges define efferent branchial channels in anterior portion of buccal cavern.

Merus of external maxillipeds pointed anteriorly, its borders sloping obliquely backwards, making together an angle of 90° (approximately). Chelipeds equal in female (male not known); fingers not hollowed at tips. Walking legs with the upper border of the merus, carpus and propus and the lower border of merus and propus cristate.

Abdomen of male not known.

Carapace length (including rostral lobes) of only specimen known is 32·50 millims.

This new genus bears considerable resemblance in general appearance to the genus *Zozymus*; the sculpture of its carapace and chelipeds, and its cristate walking legs, are reminiscent of *Zozymus æneus*. It presents, however, many points of difference from that genus.

These differences concern :—(1) Plane of the posterior half of the dorsal surface of the carapace; (2) antero-lateral borders of the carapace; (3) direction in which the folded antennules lie; (4) antero-external angle of the basal antennal segment; (5) shape of anterior part of merus of external maxillipeds; and (6) finger tips.

The form of the antero-lateral borders of the carapace is, moreover, a point of difference from ALCOCK's description of the Alliance in which he places *Zozymus, i.e.*, Alliance Zozymoida (see A.3, p. 77); the character of the walking legs is a link with this Alliance. The sub-orbital continuation of the antero-lateral borders of the carapace, and the production of the outer angle of the basal antennal joint into the orbital hiatus, are links with the Alliance Euxanthoida. The pentagonal form of the carapace is a point of similarity to the Alliance Halimedoida. (See NOBILI for figure of *Halimede hendersoni*—N., p. 123, pl. vi., fig. 31.)

Demania splendida, n. sp.—Plate I., fig. 8, and Plate II., fig. 1.

Locality :—Trincomalee, a single non-ovigerous, but probably adult, female.

Description :—Carapace roughly pentagonal, with prominent deeply notched front and rounded epibranchial angles; the antero-lateral borders are convex, the postero-lateral borders concave, the posterior border slightly concave.

The general surface is convex fore and aft; it is also convex from side to side—quite obviously so in the hepatic regions, only slightly so in the branchial regions. The regions are well delimited by pubescent grooves, and are themselves broken by similar grooves into numerous lobules; the latter are more numerous and more distinctly demarcated in the posterior half; in the anterior half they are often more or less confluent, the separating grooves dying away. The lobules are all smooth and polished, and the grooves are found on removal of the pubescence to be smooth. The carapace has thus a general resemblance to that of *Zozymus æneus*.

The front is considerably produced and deeply divided to form two prominent bluntly pointed lobes: at the base of the outer border of each of the latter the outer angle of the front is produced as a distinct, blunt, forwardly directed tooth. Frontal breadth ÷ C.l. = 0·31; length of frontal lobe (inner border) ÷ frontal breadth = 0·27.

Orbital border smooth. Upper border has tumid inner portion. There are three fissures—one a little to outer side of the middle point of the upper border, the other two are in the neighbourhood of the outer angle, one above and one below. The inner orbital angles, both upper and lower (the latter a blunt tooth), are prominent; the intervening hiatus receives only a narrow projection of the outer angle of the basal antennal segment.

Antero-lateral border of carapace rounded; the actual edge shows a slight sharpening,

and there is a suggestion of its continuance anteriorly below the orbit to the antero-external angle of the buccal cavern. It is divided by grooves into four sufficiently distinct, but little-prominent, lobes; the groove between the 1st and 2nd lobe is the least distinct.

Under surface of carapace smooth and polished, and lobulated as dorsal surface. A distinct groove runs obliquely backward from the region of the green gland aperture, to end at the border of the carapace just above the base of walking leg 4. There is a patch of hair above the base of the chelipeds, and a fringe follows the edge of the carapace above the bases of the walking legs, and skirts abdomen.

Thoracic sternal region is in its exposed portion broken by transverse pubescent grooves into regions appropriate to the segments bearing chelipeds and four walking legs. There is some tendency to subdivision of these regions (see figure), and the surfaces are polished and show some dimples.

Abdomen.—The seven abdominal terga are separate. Tergum VI. is about twice as long as any of the first five (which are subequal in length) and of approximately the same length as tergum VII. In addition to a little dimpling, each tergum is traversed by a pubescent transverse groove, before and behind which, in the case of VI., is a slightly marked additional groove. The abdomen is well fringed with hair.

Antennules fold obliquely—making an angle of 40° (approximately) with a horizontal line.

Antennæ.—Basal antennal segment, as a whole, falls short of the inner orbital angles; its outer angle, however, is produced into the hiatus; its inner angle touches a downgrowth of the front. The orbital hiatus thus remains open for the most part, and in it is seen the short antennal flagellum (flagellum length ÷ C.l. = 0·11).

External Maxillipeds.—See figure. The merus is of approximately the same breadth as the ischium and about one half as long; it is pointed anteriorly, its borders sloping obliquely backwards and making together an angle of 90° approximately. The flagellum arises from the inner side of the apex. A longitudinal groove traverses both merus and ischium. The surface of the external maxilliped is polished.

Chelipeds of equal size. The upper, outer, and under surfaces of the arm, wrist, and hand are subdivided by pubescent grooves into polished lobes somewhat reminiscent of brain convolutions. The inner surface of the arm is smooth, and is concave in correlation with the convex under surface of the carapace; on the sharp inner border of the merus are three blunt teeth (exclusive of the distal angle), the same border has a fringe of hair; the upper border is also sharp; the inner border is well rounded. The length and breadth of the upper surface of the wrist are equal, its inner anterior angle is produced into a tooth, to the inner side of which is a much smaller one; the upper and outer surfaces form a continuous curve. The upper border of the hand is armed with a row of six or seven blunt teeth, or tubercles (six on right hand, seven on left hand); the grooves of the hand, transverse in the main, are crossed by two which are longitudinal (one running to the outer side of the base of the dactylus,

the other to the base of the inter-digital cleft). The fingers have pointed tips, they meet throughout their length; apposed borders are toothed throughout, the distal teeth being the larger; when clenched, the inner surfaces of the fingers taken together are concave; an irregular pubescent groove runs along the proximal portion of the upper surface of the dactylus.

Walking legs flattened laterally, the dorsal border of meropodite, carpopodite, and propodite in each is expanded as a considerable crest; the ventral border of the meropodite of each has distally two ridges, the anterior of which extends the whole length of the segment, and is more prominent proximally, particularly in walking leg 4; in walking leg 4, also, the ventral border of the propodite is expanded, so that the segment is foliaceous; there are traces of transverse grooves on the posterior surfaces of the meropodites of all the walking legs; the posterior surface of the propodite is dimpled.

The dactylopodites of the first three pairs are fairly similar, somewhat compressed antero-posteriorly, both anterior and posterior surfaces with a longitudinal groove, dorsal border flattened and bearing a mat of short hairs. The dactylopodite of walking leg 4 is foliaceous, but its flattened surface is only 0·36 as broad as that of the propodite of the same appendage. There is a tuft of hair on the dorsal border of the proximal portion of the meropodite of each walking leg.

C.b. (rostral lobes included) = 32·50; Front.b. ÷ C.l. = 0·31; Fronto-orb.b. ÷ C.l. = 0·58. C.b. ÷ C.l. = 1·11; Front.b. ÷ C.b. = 0·32; Fronto-orb.b. ÷ C.b. = 0·50. Ant.lat.bord.C. ÷ C.l. = 0·43; Post-lat.bord.C. ÷ C.l. = 0·58; Post.bord.C. ÷ C.l. = 0·52. Ch.l. (*i.e.*, Arm l. + Propus l.) ÷ C.l. = 1·30; Arm l. (lower border, condyle of basal joint included) ÷ C.l. = 0·58; Propus l. (lower border) ÷ C.l. = 0·72.

Lophozozymus incisus (H. Milne-Edwards, 1834)—A.3, p. 107.

Locality:—Gulf of Manaar, one specimen.

Description:—An adult male. C.l. = 15·0.

Lophozozymus dodone (Herbst, 1801)—A.3, p. 108.

Localities:—Off Mutwal Island, two specimens (adult ♂, adult ♀); coral reefs, Gulf of Manaar, two specimens (adult ♂); pearl banks, Gulf of Manaar, two specimens (♂, ? young); Trincomalee, two specimens (young ♂, young ♀).

Description:—Variability among the specimens concerns:—(1) Index C.b. ÷ C.l.; and (2) the fact that most are somewhat concave laterally, but an adult male has approximately straight sides.

Lophozozymus pulchellus, A. Milne-Edwards, 1867—('Nouv. Arch. Mus.,' ix., p. 205).

Locality:—Galle, one specimen.

Description:—Adult female. C.l. = 10·5. It is covered with a pubescence. The most anterior of the three antero-lateral teeth is obsolescent. Traces of the network of red lines are seen in the posterior and postero-lateral regions with a lens.

Remarks.—This species is new to the Indian fauna. It may conveniently be separated from all other Indian forms by having the edge of the antero-lateral border of the carapace rounded in its anterior portion.

Euxanthus herdmani, n. sp.—Plate I., figs. 9, 9*a*.

Locality :—Pearl banks, Gulf of Manaar, one specimen.

Description :—An adult male. C.l. (including frontal lobes) = 23·00.

The lobules of the carapace are strongly convex, 2L more prominent than the others; they are dimpled, but 3M very slightly so: there is a fine pitting on the anterior part of the surface of the carapace, producing a dull appearance; the posterior part is glazed. The antero-lateral border is cut into four blunt tubercular teeth, the hindermost of which is smaller than the other three, which are of sub-equal size; the sub-orbital continuation of the border is indistinct. The curve of the orbit is unbroken by any denticle at the outer angle, and is seen by the lens to be finely granular.

The exopodite of the external maxilliped is granular, so is the outer proximal part of the ischium and the free border of the merus. The longitudinal groove of the ischium and that of the merus are both deep. The outer surfaces of the wrist and hand, as of the corresponding segments of the legs, are nodular, both nodules and the hollows between them being smooth. The outer surface of the wrist is rounded, with the nodules faintly marked (by no means so obvious as in *E. melissa* or *E. sculptilis*). The inner surface of hand, wrist, and arm is flattened and smooth; the upper surface of the hand has two nodules distally behind the finger joint, and a third posteriorly just in front of the wrist joint. Running obliquely backward and outward from the outer of the two distal nodules is a series of three others, from each of the first and third of which runs forward a wrinkled non-granulated line. The fingers have strongly toothed cutting edges, the distal end of the fixed finger is hollowed on the inner side of the teeth; the proximal portion of the upper surface of the dactylus is granular.

The upper and lower borders of the walking legs and the upper border of the arms are fringed with hair; the fringe is replaced on the upper border of the dactylopodites of the walking legs by a close-set covering of short hairs.

C.l. (rostral lobes included) = 23·00; C.b. ÷ C.l. = 1·33; Fronto-orbital b. ÷ C.l. = 0·71; Antero-lateral border (a straight line uniting the outer angle of orbit with the tip of the 4th antero-lateral tooth) ÷ C.l. = 0·62; Postero-lateral border (a straight line uniting the tip of the 4th antero-lateral tooth with the point at which the carapace border meets the 1st abdominal tergum) ÷ C.l. = 0·53; Posterior border of carapace (line of junction with abdominal tergum 1) ÷ C.l. = 3·04.

Remarks.—Among forms hitherto described the new species comes nearest to *E. melissa* in general character of the lobules of the carapace and in the absence of the denticle at the outer angle of the orbit. It is somewhat intermediate in the

sculpture of its hands and fingers, between *E. melissa* and *E. sculptilis.* It differs from forms hitherto described in:—(1) Ratio of C.b. ÷ C.l.; (2) the more produced frontal lobes (see figure); (3) the antero-lateral border of the carapace has only four tubercles. The latter point is useful for purposes of key. The anterior of the antero-lateral teeth seems to take the place of the first two antero-lateral tubercles of *E. melissa* or of *E. sculptilis* and of a third tubercle to the inner side of these on the dorsal surface of the carapace, which is distinct in both the species named. Correlated with this arrangement is the more regular curve made by the front and the antero-lateral borders.

The form of the front is not unlike that of a specimen of *Hypocolpus rugosus* in the British Museum, in which, moreover, there are only four indistinct lobes on the antero-lateral border. There is a faint depression on the ventral surface behind the orbit and to inner side of 1st antero-lateral tooth. This does not represent the curious deep cavity found in *Hypocolpus*, for both are present in *H. sculptus* (*i.e.*, in British Museum specimen from Mauritius 84.8).

Hypocolpus [= Hypocœlus] rugosus, HENDERSON, 1893—A.3, p. 111.

Locality:—Coral reef, Gulf of Manaar, two specimens (ovigerous ♀ and adult ♂).

I note (1) granules of carapace are larger than in a specimen of *H. granulatus* in the British Museum instead of smaller as in HENDERSON'S description; (2) the three teeth of the antero-lateral border of the carapace are not so obvious as in HENDERSON'S figure, and in the adult ♂ (*b*) an additional small tooth occurs between the 2nd and 3rd larger ones counting from before backwards. In the adult ♀ (*a*) there is a mere trace of this additional tooth.

A point of difference between the present specimen of *H. rugosus* and the British Museum specimen of *H. granulatus* is that in the former the sternal area on either side of the flexed abdomen has an eroded appearance, while in the latter it is covered irregularly by distinct granules.

Xantho distinguendus, DE HAAN, 1835—A.3, p. 113.

Localities:—Coral reefs, Gulf of Manaar, one specimen (*a*); south of Galle, deep water, three specimens (*b*, *c*, *d*).

Description:—Specimen (*a*) is an adult male, C.l. = 6·0; specimens (*c*) and (*d*) are non-ovigerous adult females; specimen (*b*) is male, with a parasitic *Sacculina*.

Remarks.—On comparing with DE HAAN'S example, one notes (1) the much smaller size, and (2) that the posterior surface of the meropodite of the walking leg 4 is smooth instead of granulated. They thus tend to agree with MIERS' "Challenger" specimens which he called *Lophozozymus bellus*, var. *leucomanus*, but are still smaller. This species is the *L.* (*Lophoxanthus*) *leucomanus* of LANCHESTER. The *Sacculina* attached to the male specimen (*b*) does not seem to have affected the sexual characters of its host; the male appendages and the general shape of the abdomen are much as in specimen (*a*), and no abdominal appendages appropriate to the female are developed.

Xantho (Leptodius) exaratus (H. M.-Edw., 1834)—A.3, p. 118.

Locality :—Trincomalee, one specimen (female, doubtfully adult).

Description :—It answers to Alcock's description. Comparing with Kossmann's figures, its greatest carapace-breadth is across the region of the 3rd, not the 4th, lateral teeth.

Cycloxanthops [= Cycloxanthus] lineatus, A. M.-Edw., 1867—A.3, p. 124.

Localities : Coral reef, Gulf of Manaar, three specimens (*a*, *b*, *c*) ; Cheval Paar, one specimen (*d*) ; off Kaltura, one specimen (*e*).

Description :—All are males, apparently adult. The spirit has removed the colour, but the specimens give evidence (under lens) that there are colour varieties within the species.

A. In specimens (*b*) and (*d*) there are faint whitish lines on the carapace in the positions represented in A. Milne-Edwards' figure.

B. In specimens (*a*) and (*e*) the carapace is covered with large spots a little darker than the general surface, each of which is surrounded by a whitish ring.

C. Specimen (*c*) has neither lines nor spots.

Polycremnus ochtodes (Herbst, 1783)—A.3, p. 135.

Localities :—Pearl banks, six specimens (three ♂, probably adult, two ♀, one young ♀) ; coral reefs, Gulf of Manaar, three specimens (two ♂, probably adult, and one ♀, probably adult).

Actæa speciosa (Dana, 1852)—A.3, p. 143.

Locality :—Gulf of Manaar, one specimen.

Description :—Female, adult, but non-ovigerous. C.l. = 6·25. It agrees with Kossmann's description and photograph of *Psaumis glabra*. It also agrees with Dana's description, but differs from his figure in some points. In mine (1) the lobe 2M is more deeply subdivided ; (2) though in the posterior portion of the carapace the grooves are very shallow and partly obliterated by granules, it is still possible to distinguish, somewhat indefinitely, the lobes 1R, 2R, 1P and 2P. There is a distinct fissure between the outer angle of the orbit and the sub-orbital border, stated by Alcock to be absent in his specimens (three, from the Persian Gulf, Ceylon, and Andamans). de Man finds this fissure in his specimen (' Abh. Senckb. Ges.,' xxv., 609).

Differences between my specimen of *A. speciosa* and the descriptions of the closely allied *A. rufopunctata* are that in the former :—(1) Carapace is relatively longer and narrower ; (2) carapace, chelipeds, and walking legs devoid of hair ; (3) lobulation of carapace much less complete and bold except on antero-lateral regions, that of chelipeds and walking legs is much as in *A. rufopunctata* ; (4) the anterior tongue of 3M reaches farther forward ; (5) the longitudinal division of 2M is hardly complete posteriorly ; (6) the groove separating 2M from 2L diverges a good deal anteriorly

from its fellow of the opposite side; (7) lobe 1P is not subdivided by a longitudinal groove and is more or less top-shaped, an anterior strip being marked off.

Actæa ruppelli (Krauss), 1843—A.3, p. 144.

Locality:—Navakaddu Paar, Gulf of Manaar, three specimens.

Actæa alcocki, n. sp.—Text-fig. 5.

Locality:—Gulf of Manaar.

Description:—An adult male. C.l. = 16·5.

The breadth of the carapace across region of last pair of antero-lateral teeth is 1·53 its length; breadth across region of next to last pair of antero-lateral teeth is 1·48 its length; frontal b. ÷ C.l. = 0·36; fronto-orbital b. ÷ C.l. = 0·64; antero-lateral border l. ÷ C.l. = 0·71; postero-lateral border l. ÷ C.l. = 0·60; posterior border l. ÷ C.l. = 0·60 (the junction of the posterior and postero-lat. border is the posterior end of a finely marked groove). The carapace and exposed surfaces of chelipeds and walking legs are covered with a short down which does not conceal the lobulation or granulation: the anterior two-thirds of the carapace are lobulated, the lobules are distinctly though not strongly demarcated by shallow grooves; on the posterior one-

Fig. 5. *Actæa alcocki*, n. sp.

third of the carapace the lobulation is obsolete. The whole dorsal surface of the carapace, grooves and lobules, and the exposed surfaces of chelipeds and walking legs, are covered with crisp, not particularly strong, granules. The lobes of the antero-lateral border are bluntly pointed, increasing in size from before backward; the first is obsolescent. The front is vertically deflexed, continuing the curve of the anterior part of the carapace; it is quite obviously bilobed; at the outer base of each lobe the inner supra-orbital angle is produced vertically downwards to form a distinct tooth. Supra-orbital margin moderately tumid, cut by two fissures in its outer portion and separated from the lower border by a third fissure.

Basal antennal segment does not quite reach the inner orbital angles.

The surfaces of the arm are smooth, a row of small sharp granules borders its lower edge. The upper and lower borders and the outer surfaces of hand and wrist (*i.e.*, the

"exposed surfaces") are granular as the carapace; the granules of the hand are the larger and are arranged in longitudinal rows on the lower half of the outer surface; the other surfaces are smooth. There is a slight transverse groove on the outer surface of the wrist behind the joint with the hand. The proximal part of the upper border of the mobile finger is roughened; there is a tooth on the biting border of each finger about one-third of its length from the base; the fingers are grooved and pointed. Distally the upper border of the hand turns abruptly downward at a right angle to the point where the mobile finger is hinged.

There is a longitudinal groove to the outer side of the upper border of the carpopodites of the walking legs. Colours in spirit ($4\frac{1}{2}$ years), yellowish, with a circular brown patch on the gastric region, and brown fingers.

The new species comes most easily into section I.i.2 of ALCOCK's key, A.3, p. 139, though carapace length = 0·66 the breadth. It is distinguished by absence of shaggy hair, the shallow nature of its grooves, the festooned appearance of its antero-lateral borders, and by its general facies.

Actæa variolosa, BORRADAILE, 1902—B.III., p. 256, fig. 54.

Localities:—Jokkenpiddi Paar, one specimen (adult ♂); Navakaddu Paar, three specimens (one adult ♂, two adult ♀).

Description:—The grooves which delimit the cardiac region laterally agree in the adult male (*b*) with their condition in BORRADAILE's figure, but in the other specimens they are more obvious—running back to a slightly indicated transverse groove parallel to and just in front of the posterior border of the carapace.

The tooth on the base of the dactylus is quite small; that on the base of the fixed finger is stout. On either side of the base of each of these teeth is a curious little tuft of dark brown hair.

Actæa peroni (H. M.-EDW.), var. **squamosa**, HENDERSON, 1893 (H., p. 357).

Localities:—Coral reefs, Gulf of Manaar, one specimen (adult ♀); Navakaddu Paar, two specimens (adult ♀ and young ♀).

Description:—Add to HENDERSON's description that there are tubercles on the front and on the antero-lateral border.

Remarks.—These specimens, from two localities, fall under HENDERSON's description of var. *squamosa*—*i.e.*, the only specimens recorded from India fall into a group having varietal distinction from ALCOCK's description (A.3, p. 150). The latter applies to the Australian variety, of which I have seen 13 specimens in the British Museum from various parts of the coast of Australia.

Actæa calculosa (H. M.-EDW., 1834)—A.3, p. 152.

Localities:—Pearl banks, Gulf of Manaar, nine specimens; off Kaltura, one specimen; Galle coral reef, one specimen; Navakaddu Paar, two specimens.

Remarks.—I consider *A. calculosa* and *A. granulata* to be distinct species. Comparing the present series of the former with a series of over 20 specimens of the latter in the British Museum, I find that though the differences are individually slight, they are numerous, constant and highly correlated. A series of differences between the two species has been set forth by CALMAN (C., p. 8).

I have seen MIERS' specimens in the British Museum, for the reception of which he made *Euxanthus tuberculosus*; as CALMAN points out, they certainly = *A. calculosa.*

Actæa granulata (AUDOUIN, 1826)—A.3, p. 151.

Localities:—Off Negombo, Gulf of Manaar, two specimens; coral reefs, Gulf of Manaar, one specimen.

Xanthias [= Xanthodes] lamarcki (H. M.-EDW., 1834)—A.3, p. 157.

Locality:—Galle, lagoon, four specimens (two adult ♂, two young ♀).

Xanthias [= Xanthodes] notatus, DANA, 1852—A.3, p. 158.

Locality:—Chilaw Paar, one specimen.

Description:—Adult male; agrees well with ALCOCK'S description. In comparing with DANA'S figure it may be noted that, both in ALCOCK'S description and in the present specimen, the last two antero-lateral teeth are procurved and spine-like. The 3rd tooth is in this specimen the longest.

Chlorodiella [= Chlorodius] niger (FORSKÅL, 1755)—A.3, p. 160.

Localities:—Trincomalee, one specimen (*a*); Palk Bay, one specimen (*b*).

Description:—Specimen (*a*) is a small male (? immature), C.l. = 6·50; specimen (*b*) is an ovigerous female, C.l. = 9·25. In both examples the last two antero-lateral prominences are blunt teeth (sharper than the 1st and 2nd teeth of the series in (*a*), much as 2nd tooth in (*b*)). They do not terminate in "procurved spine-like points" as in the examples described by ALCOCK. In specimen (*a*) there is neither spine nor tubercle on the anterior border of the arm.

Phymodius sculptus (A. M.-EDW., 1873)—A.3, p. 164.

Locality:—Coral reef, Galle, two small males.

Chlorodopsis areolata (H. M.-EDW., 1834)—A.3, p. 166.

Localities:—Galle, two specimens (adult ♀ and adult ♂); Galle, lagoon, one specimen (young ♀).

Description:—In the adult female, C.l. = 9·50; C.b. ÷ C.l. = 1·42; Frontal b. ÷ C.l. = 0·66; Frontal l. ÷ C.b. = 0·46.

The female of this species is figured by DANA under the name *Etisodes cælatus.*

Chlorodopsis pilumnoides (WHITE, 1847)—A. 3, p. 167.

Localities:—Coral reefs, Gulf of Manaar, six specimens; Navakaddu Paar, four specimens; Jokkenpiddi Paar, two specimens; Muttuvaratu Paar, six specimens.

Description:—The above include six adult males, one young male, three ovigerous females, six adult non-ovigerous females, and two young females. C.l.ovig. ♀ = 9·5.

Pilodius pugil, DANA, 1852—('U.S. Expl. Exp.,' Crust., I., 1852, p. 219, pl. xii., fig. 8.)

Locality:—Gulf of Manaar, one specimen.

Description:—An adult male. C.l. = 10·0.

Cymo andreossyi (AUDOUIN), 1826—A.3, p. 173.

Locality:—Gulf of Manaar, one specimen.

Description:—Adult male, C.l. = 6·50.

Calmania, n. gen.

Carapace subcircular, its length and breadth about equal; it is convex antero-posteriorly, less so from side to side; the only region distinctly indicated is the cardiac, which is delimited anteriorly and antero-laterally by an obvious groove. The antero-lateral border is indistinctly four-lobed.

Fronto-orbital breadth about two-thirds the greatest carapace breadth. Frontal breadth about one-third the greatest carapace breadth. The front is rounded anteriorly, continuing the general antero-lateral curve of the carapace: it is very distinctly bilobed; the lobe of either side is not separated by notch or groove from the orbital border. One of the two supra-orbital grooves is present, the other indicated merely. Eyes on short thick stalks.

The fold of the antennules is longitudinally oblique, making an angle of a little less than 45° with a perpendicular line.

The basal antennal segment falls short of the orbital hiatus, into which its outer angle is not produced. The antennal flagellum slender and naked; it is about $\frac{1}{4}$ C.l.

No ridges define efferent branchial channel in anterior portion of buccal cavern.

The merus of the external maxillipeds is broader than long. The ischium is slightly longer than broad. The outer angle of the merus is rounded.

Chelipeds equal (a non-ovigerous, but quite probably mature, female only known), not long, but very massive, the fingers remarkably large, gaping proximally, their tips pointed; the upper border of the hand bears two prominences—the distal of the two is particularly enlarged. The walking legs are approximately the same length as the cheliped; they are fringed with silky hair.

It is a little difficult to find relatives for the new genus. I place it among the Xanthidæ, as having the anterior epistomial margin of the buccal cavity well defined and not overlapped by the external maxillipeds, and the antennal flagellum slender; it differs, however, from the usual Xanthid form in the greater length of its antennal

flagellum and in the longitudinally oblique fold of the antennules. The latter characters and the general *Kraussia*-like shape of the carapace suggest Cancrid affinities. It may possibly fall into the sub-family Chlorodinæ (A.3, p. 78); but it does not agree with any of the three Alliances into which ALCOCK divides the sub-family, but the obliquely folding antennules of *Cymo* are to be remembered. From *Cymo*, however, the new genus presents many points of difference.

Calmania prima, n. sp.—Plate I., fig. 12, *a–c*.

Locality :—Gulf of Manaar, one specimen.

Description :—A female, non-ovigerous, but quite probably adult.

C.l. = 7·0 ; C.l. ÷ C.b. = 0·93 ; the only region distinctly indicated is the cardiac, which is delimited anteriorly and antero-laterally by a well-marked groove ; a fainter groove completes the isolation of the branchial regions anteriorly, a groove runs back in the middle line from the notch between the frontal lobes. There are four tufts of hair on the dorsal surface of the carapace, one on each side of the gastric region and one behind and to outer side of each of these. The antero-lateral border of the carapace is sharpened, almost cristate, and has three slight teeth behind the external orbital angle, which faintly indicate a division into four lobes.

Fronto-orbital b. ÷ C.b. = 0·71 ; frontal b. ÷ C.b. = 0·46. For further description of front see generic description ; it is fringed by long silky hairs.

The folded antennule makes an angle of 40° approximately with a perpendicular line. The antennal flagellum is slender and naked. Ant.flag.l. ÷ C.l. = 0·25, approx.

For external maxillipeds, see description of genus. The ischia do not quite meet.

Ch.l. ÷ C.l. = 1·22 ; the massive hand and fingers are remarkable ; the fingers are bent on the hand somewhat as in *Lambrus* ; when closed, the distal halves of the fingers meet, but between the proximal halves there is a rounded gap left ; the distal apposable part of both fingers is dentate. The inner surface of the hand is smooth and polished ; the outer surface of hand and fingers is richly sculptured ; both above and below an intermediate region of outer surface of hand is a groove bordered on both edges by a granular line. On the upper border of the wrist is a row of granules. The sculpture of the hand and fingers is hidden a good deal by hair ; long silky hairs are found also on the upper border of the hand, and a tuft on the outer surface of the wrist.

The walking legs are of approximately equal length, 2nd walking leg l. ÷ C.l. = 1·20 ; they are a little compressed laterally ; their surface is smooth and glazed ; their borders are fringed with silky hair.

Ozius rugulosus, STIMPSON, 1858—A.3, p. 182.

Locality :—Galle, one specimen (adult ♀).

Ozius tuberculosus, H. M.-EDW., 1834—A.3, p. 183.

Locality :—Trincomalee, one specimen.

Description:—An adult male. The central part of the carapace is smooth, *i.e.*, the pearly tubercles are here absent.

Epixanthus frontalis (H. M.-Edw., 1834)—A.3, p. 185.

Locality:—Trincomalee, two specimens (*a*, *b*).

Description:—	C.l.	C.b. ÷ C.l.	Frontal b. ÷ C.l.	Frontal b. ÷ C.b.
(*a*) adult ♂ . . .	13·25	1·64	0·57	0·34
(*b*) ovigerous ♀ . .	16·00	1·62	0·56	0·35

Pilumnus vespertilio (Fabricius), 1793—A.3, p. 192.

Locality:—Trincomalee, one specimen.

Description:—An adult male, C.l. = 19·0. The sub-hepatic denticle of the right side is double, and that of the left side is represented by a group of three granules.

Pilumnus longicornis, Hilgendorf, 1878—A.3, p. 193.

Locality:—Gulf of Manaar, two specimens.

Description:—Both adult males.

Pilumnus cursor, A. M.-Edw., 1873—A.3, p. 195.

Locality:—Gulf of Manaar, one specimen.

Description:—Female, probably adult. C.l. = 8·00.

This specimen agrees very fairly with Alcock's description of the samples which he puts with a query under this species. However, an area occupying the distal part of the lower portion of the outer surface of its larger chela (say one-third of whole outer surface) is naked and polished. Its fingers are dark brown.

Actumnus setifer (de Haan), var. **tomentosus** (Dana), Miers—A.3, p. 202.

Locality:—Pearl banks, Gulf of Manaar, four specimens (including *a*); off Mutwal Island, two specimens (*b*, *c*); south of Modragam, one specimen.

Description:—The series includes six males—all perhaps adult—and one ovigerous female. C.l. of the latter = 5·5.

In male specimen (*a*) the denuded carapace appears smooth to the naked eye, but fine granules are revealed by the lens. A similar fine granulation occupies the central part of the carapace of males (*b*) and (*c*), in both of which an antero-lateral strip is granular to the unaided eye. Distinctness of areolæ possesses high variability; specimens (*c*), (*a*), and (*b*), together with a Torres Straits specimen in the British Museum, form a series linking *tomentosus* and *setifer* in respect of this character.

Remarks.—The evidence of the British Museum specimens and of those before me compels me to consider, with Miers ("Alert," p. 225), that *tomentosus* and *setifer* are a single species. Alcock kept them apart, however, and in so doing he had before him 32 specimens of the former and 53 of the latter. It would be interesting to have some exact knowledge of variability within such considerable samples.

Actumnus setifer (DE HAAN), var. **setifer**—A.3, p. 202.

Localities:—Pearl banks, Gulf of Manaar, one specimen (adult ♀); deep water off Galle, one specimen (ovigerous ♀); Trincomalee, one specimen (ovigerous ♀).

Description:—In these specimens the areolæ are more distinct than in the figures of either DE HAAN or of A. MILNE-EDWARDS. Moreover, the tomentum gives place to a slight pubescence, and the general appearance is reminiscent of *A. verrucosus*, HENDERSON, from which the specimens may, however, be distinguished as in ALCOCK'S key by having the lobule of the lateral gastric region semicircular instead of ω-shaped.

Remarks.—The specimens suggest that an examination into the specific distinctness of *A. setifer*, *A. bonnieri*, and *A. verrucosus* is desirable.

Actumnus verrucosus, HENDERSON, 1893—A.3, p. 203.

Localities:—Pearl banks, Gulf of Manaar, 25 specimens; coral reefs, Gulf of Manaar, five specimens; Muttuvaratu Paar, one specimen.

Remarks.—There is in the British Museum a single adult male specimen of this species labelled in MIERS' (?) writing "*Actumnus ceylonicus*, MIERS—Ceylon. Presented by E. W. H. HOLDSWORTH, Esq.—1875." I am not aware that he published any description of the crab.

A. verrucosus is very closely allied to *A. setifer* on the one hand and to *A. bonnieri*, NOBILI, 1905, on the other.

Actumnus bonnieri, NOBILI, 1905—(N., p. 132, pl. vi., fig. 32).

Localities:—Pearl banks, Gulf of Manaar, two specimens (one adult ♀); deep water off Galle, one specimen (ovigerous ♀).

The present examples of *A. bonnieri* agree well with NOBILI'S description and photograph. They are smaller than the average of *verrucosus* specimens known to me. The difference between the two species in question is mainly a difference in the form of the lateral gastric lobe. A similar distinction does not separate it from *A. setifer*, though other differences hold here.

Apart from the characteristic ω-shaped lateral gastric lobe of *A. verrucosus*, the characters which separate *A. setifer* var. *tomentosus*, *A. setifer* var. *setifer*, *A. verrucosus*, and *A. bonnieri* from each other are highly variable. An exact knowledge of the variation within large samples is very desirable. Such variable characters are:—(1) C.b.÷C.l., (2) convexity of carapace, (3) distinctness of areolæ, (4) hairiness of carapace, (5) condition of outer angles of front, (6) condition of fissure in lower orbital margin (?), (7) granulation of wrist.

Actumnus fissifrons, ALCOCK, 1898—A.3, p. 204; A. Invest., pl. xxxvii., fig. 5.

Locality:—Deep water off Galle, one specimen (adult ♂).

Trapezia cymodoce (Herbst, 1801)—A.3, p. 219.

Localities :—Muttuvaratu Paar, four specimens (*e*, *f*, *g*, *h*); Jokkenpiddi Paar, one specimen (*k*); coral reef, Galle, twelve specimens (*m*, *n*, *p*, *q*, *r*, *s*, *t*, *u*, *v*, *w*, *x*, *y*); pearl banks, Gulf of Manaar, eight specimens (*a*, *b*, *c*, *d*, *i*, *j*, *k*, *o*).

Description :—Alcock's observation, that the carapace of the adult female is more curved than that of the male, is reversed in the present series. Variation concerns—(1) size: the size of adult specimens varies a good deal, *e.g.*, two adult males C.l. = 6·25 and 16·0, and two ovigerous females C.l. = 5·75 and 10·75; (2) the outer angles of the frontal lobes: these are entire in most, but crenulate in adult male (*i*) and in ovigerous female (*b*), and they tend to be so also in (*j*) young ♀, (*m*) ovigerous ♀, and (*n*) adult ♂; (3) the outer orbital angle is in most cases produced and pointed, but in the adult male (*k*) and also in (*p*), (*q*), and (*r*) it is blunt, in ovigerous ♀ (*v*), ovigerous ♀ (*x*), and adult ♂ (*y*) it is only slightly produced, and in adult ♂ (*w*) it is not produced; (4) the lateral epibranchial spine is quite obvious and sharp in most cases, but in (*k*), (*p*), (*q*), and (*r*) it is blunt, while in (*v*), (*x*), and (*y*) it is obsolescent. It will be noted that variation of outer orbital angle and of lateral epibranchial spine are correlated.

A specimen (*z*) from "Lagoon, Galle, 1903," may be conveniently included here as a variety. In it the lateral epibranchial tooth of the carapace is absent, the antero-lateral borders diverging posteriorly to form a continuous curve with the anteriorly divergent postero-lateral borders. The hand is naked. The front agrees fairly with that of *T. ferruginea* or *T. cymodoce*. I would name it var. *edentula*.

Another specimen (*z''*), a doubtfully mature male, has the merest trace of a lateral epibranchial tooth and a rather strongly reflected front.

Remarks.—The specimens (*p*), (*q*), and (*r*) combine the outer orbital angle, the lateral epibranchial tooth, and the inner sub-orbital tooth of *ferruginea* with the hand of *cymodoce*. The front is intermediate in character. The specific distinction between the two species is thus minimised. Judging from my specimens and from those in the British Museum, the best distinction is the hair of the hand.

Trapezia ferruginea, Latreille, var. **areolata,** Dana, 1852—A.3, p. 221.

Localities :—Coral reef, Galle, two specimens; Trincomalee, one specimen; Cheval Paar, two specimens; Jokkenpiddi Paar, two specimens.

Description :—C.l. of an ovigerous female = 12.

Trapezia maculata (Macleay, 1838)—A.3, p. 221.

Locality :—Jokkenpiddi Paar, two specimens (young ♂ and young ♀).

Trapezia rufopunctata (Herbst, 1799)—A.3, p. 222.

Locality :—Jokkenpiddi Paar, one specimen.

Description :—An ovigerous female, C.l. = 13.

Tetralia glaberrima (HERBST, 1790)—A.3, p. 223.

Localities :—Galle, one specimen ; pearl banks, Gulf of Manaar, two specimens ; Navakaddu Paar, two specimens ; Muttuvaratu Paar, one specimen ; off Mutwal Island, one specimen.

Description :—The above include three ovigerous females, one young female, one adult male, and two doubtfully young males.

Quadrella coronata, DANA, var. **granulosa**, BORRADAILE, 1902 (B.III., p. 266).

Locality :—Gulf of Manaar, six specimens ; Galle, deep water, three specimens.

Description :—C.l. of two ovigerous females = 7·0 and 13·75.

Portunus tuberculatus, ROUX, 1830.

Locality :—Deep water off Galle and onwards, one specimen.

Remarks.—This genus (*i.e.*, the *Portunus* of FABRICIUS) is new to the Indian fauna.

Lissocarcinus polybioides, ADAMS and WHITE, 1848—A.4., p. 19.

Localities :—South-east of Modragam, on weed-bearing oyster spat, one specimen (adult ♂) ; Gulf of Manaar, two specimens (ovigerous ♀ and young ♂).

Description :—C.l. of ovigerous female = 9·5.

Lissocarcinus orbicularis, DANA, 1852—A.4, p. 20.

Localities :—Negombo, one specimen (ov. ♀ *a*) ; Galle, lagoon, one specimen (adult ♀ *b*).

Description :—C.l. of ovigerous female = 12·00.

Specimen (*a*) is labelled "black crab from mouth of Trepang," and specimen (*b*), which is wound about with Holothurian threads, bears the label "black and white crab from rectum of black Holothurian."

Lissocarcinus lævis, MIERS, 1886—A.4, p. 21.

Localities :—Pearl banks, Gulf of Manaar, ten specimens (*a* to *g* and *n* to *p*) ; coral reefs, Gulf of Manaar, six specimens (*h* to *m*).

Description :—The difference in size between (*a*) and (*b*), both adult females (the latter ovigerous), is to be noted. C.l. of (*a*) = 11·00 ; C.l. of (*b*) = 7·00. Apart from this, variability is low in the above series.

Lupocyclus rotundatus, ADAMS and WHITE, 1848—A.4, p. 23.

Localities :—Off Kaltura, two specimens (*a*, *b*) ; deep water off Galle, four specimens ; coral reef, Gulf of Manaar, ten specimens (including *c*).

Description :—The series includes three ovigerous females, three adult non-ovigerous females, three young females, five adult males, and two young males. C.l. of an ovigerous female = 10·00.

In the above specimens there are indications of ridges in similar positions to those

of *Neptunus* (*Lupocycloporus*) *whitei*, except that the anterior gastric ridge of the latter is not represented.

In ovigerous female (*c*) and in adult male (*a*) the three posterior of the interdental denticles are excessively rudimentary; a character described by ALCOCK for the young (*i.e.*, the absence of these denticles) tends thus to survive in the adult.

Lupocyclus strigosus, ALCOCK, 1899—A.4, p. 24.

Locality:—Gulf of Manaar, three specimens (2 adult ♂ and 1 young ♀).

Description:—C.l. of an adult male (front included) = 12·00. The present examples have only five teeth on the antero-lateral margin of the carapace (outer orbital angle included) instead of six. It is the second tooth which is absent.

Neptunus (Neptunus) sanguinolentus (HERBST, 1783)—A.4, p. 32.

Localities:—Gulf of Manaar, one specimen; Trincomalee, two specimens.

Description:—Two females and a male—all young.

Neptunus (Neptunus) pelagicus (LINN.), 1764—A.4, p. 34.

Locality:—Off Chilaw, $2\frac{1}{2}$ to 4 miles off shore, one specimen (adult non-ovigerous ♀). (RATHBUN, 'Proc. Biol. Soc. Wash.,' xi., for genera of this and last species.)

ALCOCK unites *N. pelagicus* and *N. trituberculatus*. Miss RATHBUN keeps them apart ('Proc. U.S. Nat. Mus.,' vol. xxvi., p. 26, 1902). The present specimen comes under *N. pelagicus* in Miss RATHBUN'S sense. WHITELEGGE'S notes on variability should be consulted ('Mem. Austral. Mus.,' iv., p. 154, 1900). He concludes, after an examination of some hundreds of examples from Port Jackson, that the character of the median tooth is not to be used as a specific distinction between the two species. Perhaps the granulation of the carapace is much a matter of sex. This character is in the present specimen of the type described by WHITELEGGE as essentially female. ORTMANN and CALMAN have cast doubt upon the specific distinctness of *N. armatus* from the present species (C., p. 21).

Neptunus (Amphitrite) gladiator (FABRICIUS, 1798)—A.4, p. 35.

Localities:—Off Negombo, Gulf of Manaar, one specimen; off Kaltura, two specimens; Galle, one specimen; pearl banks, Gulf of Manaar, thirty specimens; coral reefs, Gulf of Manaar, four specimens; Chilaw Paar, one specimen.

Description:—There are five ovigerous females, six adult but non-ovigerous females, fifteen young females, one adult male, and twelve young males.

The present specimens are small compared with some I have seen from Madras. I give some measurements of three of the ovigerous females:—

C.l.	22·00	20·00	20·00
C.b. ÷ C.l.	1·45	1·46	1·49
Rt. lat. spine l. (anterior border) ÷ C.l.	0·12	0·17	0·17

C.b. is measured by a straight line uniting the notches between teeth 8 and 9.

Neptunus (Amphitrite) argentatus, White, 1847—A.4, p. 36.

Localities:—Deep water off Galle, one specimen (ovigerous ♀); coral reefs, Gulf of Manaar, two specimens (adult ♀, adult ♂); off Kaltura, five specimens (one ovigerous ♀, one adult non-ovigerous ♀, and three adult ♂).

Description:—C.l. of an ovigerous female = 15·50.

Neptunus (Amphitrite) petreus, Alcock, 1899—A.4, p. 37.

Locality:—Gulf of Manaar.

Description:—A young specimen (C.l. = 5·00) which I put a little doubtfully in this species. Its wrist has the strikingly elongated inner spine. A point in which it differs from Alcock's figure (A.Invest., pl. xlvi., fig. 2) is the still more blunt nature of the frontal lobes, the notches between them being wider and shallower.

Neptunus (Amphitrite) euglyphus, n. sp.—Text-figs. 6 and 7.

Localities:—Pearl banks, Gulf of Manaar, 13 specimens (*a* to *e* and *m* to *t*); coral reefs, Gulf of Manaar, four specimens (*f* to *i*); off Negombo, three specimens (*j*, *k*, *l*).

Description:—The association of a strong lateral production of the antero-external angle of the merus of the external maxilliped with rounded posterior carapace angles, and a much enlarged last spine of the antero-lateral series, show *N. euglyphus* to be a member of the sub-genus *Amphitrite* (*i.e.*, I.A.1.ii. of Alcock's key. A.4, p. 31).

Fig. 6. *Neptunus euglyphus*, n. sp.

Fig. 7. Ventral view, external maxilliped and cheliped.

It differs from *Neptunus* (*Amphitrite*) *gladiator* in the following particulars:—(1) The grooves which delimit the several regions of the carapace are more strongly marked; (2) the two median frontal teeth are closer together: they meet the dentiform process of the epistome, so producing an appearance not unlike a single dorsally grooved median tooth; (3) the large last spine of the antero-lateral series has a very characteristic appearance: it is very broad proximally, flattened dorso-ventrally, and its posterior border is strongly recurved downwards and forwards;

(4) correlated with (3) is the short postero-lateral border of the carapace; (5) the middle region of the posterior border of the arm is considerably expanded—the inner surface of the hand and of the fixed finger is granular, and the under surfaces of all segments of the cheliped have a glazed appearance; (6) walking legs 1, 2, and 3 are, as a whole, glazed, there are a few hairs along the upper border, walking leg 4 is more or less tomentose.

Remarks.—The new species is distinguished at a glance from all other members of the sub-genus by its very characteristic last pair of lateral spines. It will be noted from (5) above that the cheliped bears a considerable resemblance to that of *Neptunus* (*Achelous*) *granulatus* (H. Milne-Edwards).

I append the measurements of three adult males:—

	C.l.	C.b. ÷ C.l.	Lat. sp. (post. bord.) ÷ C.l.	Front. b. ÷ C.l.	Front.orb. b. ÷ C.l.	Ant.lat. bord. ÷ C.l.	Post.lat. bord. ÷ C.l.	Post. bord. ÷ C.l.
(*a*) . .	12·50	1·64	0·46	0·36	0·88	0·68	0·32	0·56
(*n*) . .	13·00	1·58	0·54	0·38	0·85	0·73	0·37	0·58
(*o*) . .	13·00	1·58	0·50	0·37	0·85	0·73	0·33	0·58

Antero-lateral border is from outer angle of orbit to notch between teeth 8 and 9.

Postero-lateral border is from base of posterior border of large spine to point of junction with abdomen.

Neptunus (Hellenus) hastatoides (Fabricius, 1798)—A.4, p. 38. Text-fig. 8.

Localities:—Galle, one specimen; pearl banks, Gulf of Manaar, nine specimens; off Mutwal Island, two specimens; coral reefs, Gulf of Manaar, twelve specimens; Palk Bay, two specimens.

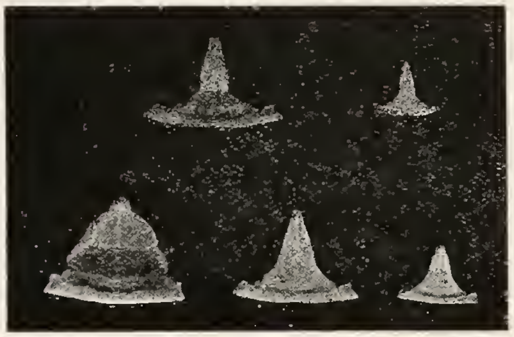


Fig. 8. Growth stages in abdomen of *Neptunus hastatoides*—upper row males, lower three females.

Description:—C.l. of an ovigerous female = 18·0.

Remarks.—Lanchester gives some account of sexual differences obtaining in this species. In view of the specimens before me I judge his figure ('Proc. Zool. Soc.,' 1900, p. 745, pl. xlv., figs. 7*a*, 7*b*) of a female abdomen to be evidently that of a young example. It agrees well with that of the young males of the present collection (see text-fig. 8).

Neptunus (Hellenus) hastatoides (Fabricius), var. **unidens**, nov.

Locality:—Coral reefs, Gulf of Manaar, one specimen.

Description:—A male, doubtfully adult, both chelipeds missing; C.l. = 12·25.

This specimen differs from other specimens of *N. hastatoides* known to me in the following particulars:—

(1) It possesses a single median frontal tooth instead of a pair, so that the front is cut into three teeth only. (This median tooth is somewhat smaller and less prominent than the lateral teeth, and its apex is flattened.)

(2) The tip of the dactylopodite of walking leg 4 is not darkened in colour (one must, of course, not overlook the possible agency of the spirit in producing this appearance).

(3) The carina of abdominal segment III. is more prominent in its middle portion and its median notch is deeper, approaching in appearance that of *N. macrophthalmus*, RATHBUN, 1903 (R., p. 871, fig. 31).

The granulation of the sternum of this male closely resembles that of the adult male of *N. hastatoides*.

Remarks.—I call attention to the absence of both chelipeds. It is therefore impossible to ascertain various essential characters. Leaving these necessarily out of consideration, the specimen is so closely similar to *N. hastatoides* (except in particulars given above) that it may be conveniently included as a varietal example of that species, in which the pair of narrow median frontal teeth have coalesced. This latter particular seems of sufficient interest to warrant my putting the specimen on record. I append the following measurements :—

$C.b._1$ (a straight line uniting the notches between the 8th and 9th antero-lateral teeth of either side) ÷ C.l. = 1·51 ; $C.b._2$ (a straight line uniting points immediately behind the great lateral spines) ÷ C.l. = 1·10 ; Posterior border of C. ÷ C.l. = 0·65 ; Frontal b. ÷ C.l. = 0·41 ; Fronto-orb.b. ÷ C.l. = 0·82 ; lateral spine l. (posterior border) ÷ C.l. = 0·49 ; antero-lateral border of C. (a straight line uniting outer orbital angle with notch between the great lateral spine and the tooth in front of it) ÷ C.l. = 0·69 ; postero-lateral border of C. (a straight line uniting base of great lateral spine with postero-lateral angle) ÷ C.l. = 0·39.

Neptunus (Hellenus) spinipes, MIERS, 1886—A.4, p. 39.

Locality :—Galle, one specimen.

Description :—An adult male, C.l. = 11·00.

Remarks.—I have examined the Martaban specimens placed by HENDERSON as *N. andersoni*, and which are preserved in the British Museum, and find that in reality they are *N. spinipes* of MIERS, whose "Challenger" specimens I have also consulted.

Neptunus (Hellenus) longispinosus (DANA), var. **bidens**, nov.—(See A.4, p. 40).

Localities :—Off Negombo, one specimen (adult ♂) ; off Mutwal Island, one specimen (adult ♂) ; Gulf of Manaar, one specimen (ovigerous ♀).

Description :—C.l. of an ovigerous female = 6·50.

In all three specimens the hand has only two spines, a point of resemblance to *Neptunus* (*Hellenus*) *tuberculosus*, A. MILNE-EDWARDS. I suggest for them the varietal name *bidens*.

The antero-external angle of the merus of the external maxillipeds and the shape of the male abdomen are evidently characters with high variability in this species if ALCOCK is correct in including both the forms figured by DANA. The present examples agree in combining a merus resembling DANA's fig. 2*c* with a male abdomen in which the borders are still more sinuous than in his fig. 3*b*—abdominal segment VI. being the one chiefly involved.

Neptunus (Hellenus) tenuipes (DE HAAN, 1835)—A.4, p. 42.

Locality :—Pearl banks, Gulf of Manaar, one specimen.

Description :—Adult male. C.l. = 16·00.

Behind the single distal spine of the outer border of the arm is a sub-terminal tubercle marking the position of the second spine of some allied species.

Neptunus (Lupocycloporus) whitei (A. M.-EDW., 1861)—A.4, p. 44.

Localities :—Coral reefs, Gulf of Manaar, two specimens (adult ♂ and adult ♀); pearl banks, Gulf of Manaar, one specimen (young ♀); off Mutwal Island (young ♀).

Description :—C.l. of adult female = 18·00.

In both the adult specimens (a ♂ and a ♀) one notes :—(1) The cardiac ridge is broken in the middle line so that it takes the form of two low broad tubercles, granulated on their posterior slope; (2) there is a small granulated protuberance on the post-gastric region; (3) there is a longitudinal row of granules on the middle line of the carapace; its anterior commencement is just in front of the break in the anterior gastric ridge, and runs back across the second gastric ridge, to terminate posteriorly between this and the third gastric ridge.

Neptunus (Achelous) granulatus (H. M.-EDW., 1834)—A.4, p. 45.

Localities :—Off Negombo, one specimen; Gulf of Manaar, 17 specimens; off Mutwal Island, one specimen.

Description :—The above specimens include four ovigerous females, five adult females, seven adult males and three young males. C.l. of an ovigerous female = 13.

There is a pearly sheen, much as in *N. argentatus*, on the crests of abdominal terga II. and III., the terminal spine of the arm, the crest of the outer surface of wrist, and the upper surface of the dactylus.

The spinule on the hand, in front of the apex of the wrist, is said by ALCOCK to be blunt. Among the present examples it is sharp, except on the left hand of two and the right hand of three specimens.

Neptunus (Achelous) dubia, n. sp.—Text-fig. 9.

Localities :—Coral reefs, Gulf of Manaar, one specimen; oft Negombo, one specimen.

Description :—Adult ♂ C.l., 13; C.b. ÷ C.l., 1·31; front.b. ÷ C.l., 3·85; front.-orb.b. ÷ C.l., 0·85; ant.lat.bord. C. ÷ C.l., 0·54; post.bord. C. ÷ C.l., 0·62; post.lat.bord. C. ÷ C.l., 0·58; Ch.l. ÷ C.l., 2·00.

It differs from *Neptunus* (*Achelous*) *granulatus* in the following characters:—(1) The outer fissure of the supra-orbital margin is obsolete; (2) the nine teeth of the antero-lateral border gradually decrease in size from before backwards; (3) the antero-lateral angle of the merus of the external maxillipeds is rounded and but slightly produced in a lateral direction; (4) the chelipeds in the male are about twice the length of the carapace, the posterior border of the arm is more expanded than in *N. granulatus*, the anterior border of the arm bears three well-developed spines and a fourth inconspicuous one posterior to these, the posterior border bears one spine only in the position of the distal one of *N. granulatus*; (5) the outline of the abdomen of the male is triangular, abdominal terga II. and III. both have well-marked carinæ, across abdominal tergum V. runs a transverse ridge just anterior to the joint between terga V. and VI.—this is correlated with the form of the copulatory appendages; (6) the form of the male copulatory appendages is characteristic.

Fig. 9. *Neptunus dubia*, n. sp., adult male.

It will be noted that in characters (1), (2) and cheliped-length the new species agrees with *Neptunus* (*Achelous*) *orbicularis*, but it differs from the latter and resembles *N. granulatus* in the granulation of its carapace and chelipeds, in the open character of the inner fissure of the supra-orbital margin, and in ratio C.b. ÷ C.l. I have not seen any specimen of *N. orbicularis*, but as points (3), (5), (6) and spines of hand, *i.e.*, part of (4), are not specified by ALCOCK as differences from *N. granulatus* in his description of *N. orbicularis* (A.4, p. 47), I conclude that the new species is sufficiently distinct from the latter.

The characters of the antero-lateral angle of the merus of the external maxilliped may be conveniently used to separate *N. dubia* from the other two members of the sub-genus given in ALCOCK's key (A.4, p. 32).

I may note here that I judge *Achelous rubro-marginatus*, LANCHESTER ('Proc. Zool. Soc.,' 1900, p. 746, pl. xlvi., fig. 8), to belong to the sub-genus *Amphitrite*, linked to the *gladiator* group by *Neptunus* (*Amphitrite*) *petreus* (A.4, p. 37). The latter species may have been unknown to LANCHESTER: its description did not long precede that of *rubro-marginatus*.

Neptunus (Pontus) convexus, DE HAAN, 1833.

Localities:—South of Modragam, one specimen; off Mutwal Island, two specimens; coral reefs, Gulf of Manaar, nine specimens; pearl banks, eleven specimens.

Description:—The above include one ovigerous female, six adult non-ovigerous females, nine young females, five adult males, and two young males. The specimens from "Coral reefs, Gulf of Manaar," are larger than those from the other localities.

Neptunus convexus is not definitely included in the Indian fauna by ALCOCK (A.4, p. 32). He suggests that its affinities are with the sub-genus *Neptunus*. It seems advisable to keep it apart, however, as the single representative of *Pontus*, a sub-genus re-defined by DE MAN ('Abh. Senckenb. Ges.,' XXV., pt. iii., p. 643, pl. XXI., fig. 27, 1902).

Charybdis (Goniosoma) natator (HERBST, 1794)—A.4, p. 61.

Localities:—Off Mutwal Island, two specimens; pearl banks, Gulf of Manaar, thirteen specimens.

Description:—The above include four females and eleven males, all young.

Charybdis (Goniosoma) orientalis, DANA, 1852—A.4, p. 63.

Localities:—Coral reefs, Gulf of Manaar, five specimens; pearl banks, Gulf of Manaar, fifteen specimens; south of Galle, one specimen; off Mutwal Island, one specimen.

Description:—C.l. of ovigerous female = 9·50.

Charybdis (Goniohellenus) ornata, A. M.-EDW., 1861—A.4, p. 64.

Locality:—Coral reef, Galle, one specimen.

Description:—The specimen is a male, C.l. = 9·75.

The last of the antero-lateral teeth is a little larger than the others instead of smaller as in ALCOCK'S description. A parasitic *Sacculina* is attached to the abdomen. On comparing the crab with one of similar size in the British Museum (ref. 73.28) I find that this has had little effect upon the form of the abdomen, but that the copulatory appendages are sensibly less developed.

Thalamita prymna (HERBST), var. **crenata** (= **T. crenata,** LATR.)—A.4, p. 76.

Locality:—Trincomalee, three male specimens.

Description:—

C.l.	29·00	38·00	41·00
C.b. ÷ C.l. . . .	1·47	1·49	1·50

The high variability in size is to be noted, as all three are possibly adult.

Thalamita prymna (HERBST), var. **annectans,** nov.

Locality:—Trincomalee, two specimens.

Description:—One is a small, but quite probably adult, male, C.l. = 16·00.

The following are its most interesting characters for systematic purposes:—(1) The fourth tooth of the antero-lateral margin of the carapace is rudimentary; (2) the ridge on the basal joint of the antenna bears spines; (3) the four middle lobes of the

front are more or less squarely cut; (4) the transverse mid-gastric ridge is not continued to the notch between the first and second teeth of the antero-lateral border of the carapace; (5) there are four ridges on the hand: two of these are ill-defined and unite the two rows of spines on its upper surface—a third corresponds in position to the third ridge of var. *crenata* and is similarly continued on to the fixed finger—the fourth is smooth, runs above the third, and ends distally just behind the cleft between the fingers; (6) there are three spines in the upper row on the palm—the distal one is smaller than the other two; (7) there is a distal spine on the wrist, just behind the upper row of spines of the palm; (8) the lower border of the propodite of walking leg 4 bears obvious spines distally; these become smaller proximally and disappear on the proximal third.

The second specimen is an immature female (Cl. = 10) which may probably be correctly put with the above. The fourth tooth of the antero-lateral margin of the carapace is seen under the lens to be excessively minute—still more rudimentary than in the male. The ridges of the hand are granular, and there is a trace of an additional ridge above the position of the one which ends interdigitally in the male.

Remarks on the species *Thalamita prymna* (HERBST). ALCOCK (1899) supports KOSSMANN'S view of the specific identity of *T. prymna* (HERBST)—*T. crenata* (LATREILLE) (including *T. crassimana*, DANA)—*T. danæ*, STIMPSON—*T. stimpsoni*, A. MILNE-EDWARDS—and *T. picta*, STIMPSON—*i.e.*, those forms with an eight-lobed front combined with a very broad basal antennal joint. Material recently described tends to justify this view. Thus CALMAN describes three series of Torres Straits forms (C., p. 22), of which two at least evidently belong to the group, and tend to combine characters of the other members rather than to belong decidedly to any recognised division. The same kind of thing occurs in the specimen of the present collection described above. It is allied by characters (1), (2), and (3) to var. *prymna*, by (4) to var. *crenata* and var. *danæ*, while characters (6) and (7) separate it from varieties known to me. ALCOCK'S key brings the present variety under var. *prymna*, from which it may readily be distinguished by characters (6) and (7) above.

Thalamita chaptali, AUDOUIN and SAVIGNY, 1826—A.4, p. 80.

Localities:—Pearl banks, Gulf of Manaar, 23 specimens; coral reefs, Gulf of Manaar, 26 specimens; off Mutwal Island, one specimen; 10 miles north of Cheval, one specimen.

Description:—C.l. of an ovigerous female = 8·25.

Thalamita poissoni, AUDOUIN and SAVIGNY, 1826—A.4, p. 81.

Localities:—West of Periya Paar, one specimen (ovigerous ♀); pearl banks, Gulf of Manaar, one specimen (adult ♂).

Description:—C.l. of the ovigerous female = 7·50.

The fourth tooth of the antero-lateral border is very rudimentary in both examples.

Thalamita admeta (Herbst, 1803)—A.4, p. 83.

Localities :—Pearl banks, Gulf of Manaar, 58 specimens ; coral reefs, Gulf of Manaar, four specimens ; off Negombo, one specimen ; off Mutwal Island, four specimens ; Muttuvaratu Paar, two specimens.

All the above specimens come under var. *admeta* as defined by Borradaile (p. 202). The fourth tooth of the antero-lateral border of the carapace, considerably reduced in all, is very rudimentary in some—particularly among the females. It is, perhaps, most rudimentary, however, in one of the adult males.

Thalamita exetastica, Alcock, 1899—A.4, p. 86 ; A.Invest., pl. xlvii., figs. 2, 2*a*.

Localities :—Pearl banks, Gulf of Manaar, two specimens (adult ♀, one ovigerous) ; south of Galle, deep water, one specimen (adult ♀).

Description :—As in Borradaile's specimens (p. 203), the squamiform markings of the cheliped are almost absent ; a trace only is present, on the upper distal portion of the arm. On the upper surface of the arm and on the upper portion of the outer surface there are more or less rounded granules ; the inner surface, the under surface, and the lower portion of the outer surface are smooth. The ridges of the carapace are well marked.

In the ovigerous female there are one or two spinules on the posterior border of the propodite of walking leg 4. This is an approach to *Charybdis orientalis*, Dana.

Thalamita integra, Dana, 1852—A.4, p. 85.

Locality :—Pearl banks, Gulf of Manaar, six specimens.

Thalamita investigatoris, Alcock, 1899—A.4, p. 85 ; A.Invest., pl. xlvii., fig. 1.

Localities :—Off Mutwal Island, one specimen ; Gulf of Manaar, deep water, three specimens ; deep water off Galle, four specimens ; coral reefs, Gulf of Manaar, one specimen (*a*).

Description :—There are five ovigerous females, one young female, one adult male, and two young males. C.l. of an ovigerous female = 7·00.

Spines are present on the propodite of walking leg 4 as described by Alcock, but omitted from his figure. As differences from Alcock's description of the single male for which he creates the species one notes that the median lobes of the front tend to have a straight rather than a rounded anterior border, and are not obviously more prominent than the sub-median pair, the latter point agreeing with Alcock's figure, however. I should not describe the fifth tooth of the antero-lateral margin of the carapace as "very" small. The wrist and hand bear more numerous spines.

The fourth tooth of the antero-lateral margin of the carapace is absent in one of the ovigerous females (*a*).

Thalamita sexlobata, Miers, 1886—A.4, p. 87.

Localities :—Pearl banks, Gulf of Manaar, eight specimens ; coral reefs, Gulf of Manaar, four specimens ; off Mutwal Island, one specimen.

Thalamita wood-masoni, Alcock, 1899—A.4, p. 90.

Locality:—10 miles north of Cheval Paar, one specimen (young ♀).

Description:—The fourth tooth of the antero-lateral margin of the carapace, which Alcock describes and figures (A.Invest., pl. xlviii., figs. 1, 1*a*) as rudimentary, is absent in the present example.

Thalamita oculea, Alcock, 1899—A.4, p. 91.

Localities:—Coral reefs, Gulf of Manaar, 10 specimens; pearl banks, Gulf of Manaar, 19 specimens; off Mutwal Island, three specimens; deep water off Galle, two specimens; off Kaltura, one specimen; Trincomalee, one specimen.

Description:—C.l. of an ovigerous female = 10·00.

Kraussia nitida, Stimpson, 1858—A.4, p. 98 (*pars*).

Localities:—Off Mutwal Island, one specimen (*a*); pearl banks, one specimen (*b*); west of Periya Paar, 17 to 24 fathoms, one specimen (young ♀).

Description:—

	C.l.	C.b. ÷ C.l.	Fronto-orb.b. ÷ C.l.
(*a*) adult ♂	12·00	1·04	0·62
(*b*) adult ♀	10·00	1·10	0·62

Miss Rathbun ('Bull. Mus. Comp. Zool.,' Harvard, xxxix., No. 5, 1902, p. 132) separates Henderson's *nitida* from this species and makes for it a new species, *Kraussia hendersoni*. The specimens of the present collection come under *K. nitida* in Miss Rathbun's sense. They agree with her figure. Miss Rathbun's photographs of species of *Kraussia* are useful (*loc. cit.* and R., 1903).

This genus is new to the Ceylon fauna. The only other genus of the family Cancridæ which I know to have been recorded from Ceylon is *Trichopeltarium*, represented by a single species (? *T. ovale*, A.4, p. 99).

I may note here that I have seen in the British Museum the "type"-specimens described by Adams and White in the 'Voyage of the "Samarang"' (p. 59, 1850) as *Trichocera porcellana*, and find that the latter name is a synonym of *K. rugulosa*. Dana puts it as such with a query (Crust., 'U.S. Expl. Exped.,' I., p. 302, 1852).

Gomeza bicornis, Gray, 1831.

Localities:—Deep water, off Galle, one specimen (*a*); pearl banks, Gulf of Manaar, six specimens (*b* to *g*).

Description:—Examples (*b*), (*c*), and (*g*) are ovigerous females, (*a*) is an adult but non-ovigerous female, and (*d*) to (*f*) are adult males.

Variability is high within the species. The present specimens fall into three groups:—(1) The non-ovigerous female (*a*, C.l. = 20) approaches A. Milne-Edwards' figure under name *Gomeza viginti-spinosa* ('Nouv. Archiv. du Mus. Paris,' vol. x., p. 52, pl. iii., fig. 5, 1874); (2) examples (*b*, C.l. = 15·5) to (*f*) agree with de Haan's figure

(Crust. in 'Fauna Japonica,' p. 44, pl. ii., fig. 5, 1835); (3) the ovigerous female (*d*, C.l. = 23) goes with the "Challenger" specimens preserved in the British Museum.

Some variable characters of the species may be set forth in the form of a key.

I. Inner sub-orbital spine small . . . . var. A.
II. Inner sub-orbital spine large.
  a. Carapace strongly pilose . . . . var. B.
  b. Hairs on carapace few or absent.
    i. Spiniform outer angle of orbit as well developed as first antero-lateral spine . . . . var. C.
    ii. Spiniform outer angle of orbit much shorter than the first antero-lateral spine . . . . var. D.

The family Corystidæ is new to the Ceylon fauna.

CATOMETOPA.

Catoptrus nitidus, A. M.-Edw., 1870—A.6, p. 307.

Locality:—West of Periya Paar, 17 to 24 fathoms.

Description:—Male, apparently adult, C.l. = 3·80; Ch.l. (smaller) ÷ Ch.l. (larger) = 0·92; C.b. ÷ C.l. = 1·51; F.l. (larger) ÷ C.l. = 1·05; Ch.l. (larger) ÷ C.l. = 0·33; F.l. (smaller) ÷ F.l. (larger) = 0·75.

Remarks.—The small size of the specimen may be noted—Alcock refers to some

	G. inæqualis, Rath.	*C. nitidus*: A.6, p. 307.	Present specimen.	*C. nitidus* (= *G. truncatifrons*, de Man).
	♂.	(Sex ?)	♂, probably adult.	♂, young.
(1) C.l.	7·00	9·50	3·80	6·20
(2) C.b. ÷ C.l.	1·51	1·53	1·51	1·66
(3) Ant. lat. region. . .	Finely granular	Finely granular	Finely granular	Coarsely granular
(4) Denticle betw. ant. lat. teeth 1 and 2	Absent	(Not mentioned)	Absent	Present
(5) Ch.l. (larger) ÷ C.l. .	3·00	—	3·03	2·50
(6) Ch.l. (smaller) ÷ C.l. .	3·40	About 3·00	3·29	Much as larger Ch.l. ÷ C.l.
(7) Ant. border arm . .	"Coarsely granulous," no spines.	Finely serrulate, one serration at either or both ends enlarged and spiniform.	Finely serrulate, one serration at prox. end enlarged and spiniform.	Granular, a spine distally in larger Ch. In smaller Ch. one behind middle also.

similarly small examples. *Goniocaphyra inæqualis*, RATHBUN, is, I believe, a synonym—her photograph gives an excellent impression of the present specimen. The preceding table shows comparative characters in these forms. ALCOCK'S description was based on 19 specimens from various localities. His measurements refer to Mauritius specimens in particular. A. MILNE-EDWARDS' "type"- specimen was large (C.b. = 23·00).

Goniocaphyra inæqualis comes under *Catoptrus nitidus* as described by ALCOCK except as regards characters (6) and (7) of table, and of these (7) is admittedly variable (even in Miss RATHBUN'S photograph there seems to be some indication of a proximal tubercle). My specimen is intermediate in regard to character 6.

Dr. DE MAN points out ('Notes, Leyden Mus.,' xii., p. 67, 1890) that his *Goniocaphyra truncatifrons* is young and = *Catoptrus nitidus*. The evidence suggests a single species for the forms included in the table, within which DE MAN'S *truncatifrons* specimen stands somewhat apart.

Mertonia, n. gen.

Description:—Carapace rudely semicircular in outline, the posterior border being the longest, and the postero-lateral borders anteriorly convergent, to form a common curve with the well-arched antero-lateral and anterior borders; it is but little broader than long, is convex fore and aft, and strongly declivous anteriorly. Regional distinctions are almost imperceptible. Fronto-orbital border more than one-half (about 0·6 in the two specimens), and front one-quarter, the greatest breadth of the carapace; front is prominent and bilobed.

Orbits somewhat ventral, completely filled by immovable elongated eye-stalks; eyes small.

Antennules small; they fold obliquely into proper pits.

Basal antennal segment fairly long, its antero-external angle stands well in the orbital hiatus; the anterior portion of the hiatus is occupied by the flagellum, which is stout and markedly plumed and half the carapace length.

The epistomial wall of the buccal cavern is well formed and prominent; the buccal cavern is not completely closed by the external maxillipeds, a considerable space being left between their inner borders, particularly those of the meri; the flagellum articulates with the antero-internal angle of the merus; the antero-external angle of the merus is produced.

Chelipeds a little unequal, much more massive than, but about the same length as, the 3rd pair of walking legs; palm short, deep, and compressed, with sharp edges.

Walking legs slender, unarmed; dactylopodites styliform: the 3rd and 4th pair of approximately equal length (the 2nd pair missing).

For key purposes *Mertonia* comes under division I.1.ii.b. of ALCOCK'S key to the Indian genera of the Rhizopinæ (A.6, p. 317). The other occupant of the same division is *Xenophthalmodes*, from which the new genus is distinguished readily by

the lateral production of the outer angle of the merus of the external maxillipeds; additional differences from the same genus concern: (1) ratio of fronto-orbital breadth ÷ C.b.; (2) ratio of frontal b. ÷ C.b.; (3) the more ventral position of the orbits: (4) eyes, though very small, are distinct; (5) direction of fold of antennules; (6) relations of basal antennal segment and orbital hiatus (associated, no doubt, with more ventral position of orbit); (7) the markedly plumed antennal flagellum. Characters (4) and (5) approach the condition found in *Typhlocarcinus*: (2) and (3) are intermediate between the latter genus and *Xenophthalmodes*.

Mertonia lanka, n. sp.—Plate I., fig. 11, *a*, *b*.

Locality:—Gulf of Manaar, two specimens (♀ and ♂).

Description:—C.l. = 4 in ♂, 4·5 in ♀; C.b. = 5·5 in ♂, 6 in ♀.

Carapace has practically smooth surface, polished, with some irregular dimpling; its free edges fringed with longish silky hairs; C.b. ÷ C.l. = 1·37 in ♂, 1·33 in ♀: frontal b. ÷ C.b. = 0·27 in ♂, 0·28 in ♀; fronto-orbital b. ÷ C.b. = 0·64 in ♂, 0·58 in ♀: front strongly declivous and decidedly bilobed.

Orbits elongated; long diameter of orbit ÷ C.l. = 0·25 in ♂, 0·28 in ♀.

The antennal hairs are numerous and long; antennal flagellum l. ÷ C.l. = 0·5 in ♂.

The buccal cavern increases slightly in breadth anteriorly; the merus of the external maxilliped has its length and breadth about equal (the measurements taken along the middle line in each case); its outer border somewhat convex; its antero-lateral angle produced and rounded; the ischium is not much longer than broad; its breadth is as that of the merus; a space is left between the ischia and a larger one between the meri (see Pl. I., fig. 11, *a*).

Chelipeds about same length as walking leg 4; hands sub-equal; inner angle of wrist acuminate; upper and lower edges of hand sharpened, its surfaces polished, with some dimpling; the edges of the chelipeds are fringed with silky hairs, these are long on the wrist, shorter on the hand. Walking legs fringed with silky hairs.

Scalopidia spinosipes, Stimpson, 1858—A.6, p. 325.

Locality:—Gulf of Manaar, one specimen.

Description:—A young male, C.l. = 5·75; C.b. ÷ C.l. = 1·30.

Pinnoteres margaritiferæ, n. sp.—Text-fig. 10, 10 *a*.

Locality:—Pearl banks, Gulf of Manaar, one specimen.

Description:—An adult male. C.l. = 5·25.

Carapace well calcified, circular, smooth, and polished; seen under lens to be pitted, more markedly so towards the margins; it is flattened a good deal, though a little convex; its margins are rounded and ill-defined. Front produced, with straight anterior border in dorsal view; its tip is really, however, deflexed acutely, and its true anterior border, seen in anterior view, is obtusely pointed. Eyes small, well pigmented; not entirely visible in a dorsal view of the animal. Propus of external

maxilliped spathulate; dactylus slender and inconspicuous, arising from about the middle of the flexor surface of the propus, which arises before the termination of the carpus, and the latter before the termination of the merus. Cheliped slightly longer than the carapace (Ch.l. ÷ C.l. = 1·12); two or three times as stout as walking leg 1, but rather shorter (Ch.l. ÷ W.L.1.l. = 0·86); the segments inflated, smooth, and

Fig. 10. *Pinnoteres margaritiferæ*, n. sp. × 3.

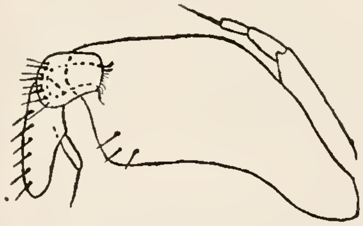


Fig. 10A. External maxilliped.

polished; dactylus is about two-thirds as long as the upper border of the hand; its tip is strongly bent down; there is a stout tooth near its base, on its apposable border.

Walking legs slender; lower borders fringed sparsely with hair. W.L.1 ÷ C.l. = 1·33; W.L.2 ÷ C.l. = 1·38; W.L.3 ÷ C.l. = 1·38; W.L.4 ÷ C.l. = 1·05. The dactyli of walking legs 1, 2, and 3 are sub-equal in length (about 0·2 of C.l.); that of walking leg 4 is about one-half as long again.

Gelasimus* annulipes, LATREILLE—A.6, p. 353—Text-fig. 11.

Locality:—Off Mutwal Island, two specimens (*a*, *b*).

Description:—	C.l.	C.b. ÷ C.l.	Post. bord. C. ÷ C.l.	Front bord ÷ C.l.	Larger propus l. ÷ C.l.
(*a*) ♂ . . .	8·75	1·66	0·91	0·29	2·17
(*b*) ♀ . . .	9·25	1·62	0·95	0·28	—

C.b. is measured by a straight line uniting produced post-orbital angles.

Posterior border C. is measured by a straight line uniting points just above and to inner side of bases of 4th pair of walking legs.

Propus length is measured along lower border.

NOBILI (in 'Boll. Mus. Torino,' xvi., No. 397, p. 13, figs. A, B, 1901) has distinguished two varieties of the species—differentiated by presence or absence of a large triangular tooth at distal end of fixed finger.

A, var. *orientalis*, NOBILI, 1901. Large tooth present.

B, var. = *Gelasimus perplexus*, A. M.-EDW., 1852. Large tooth absent.

Fig. 11. *Gelasimus annulipes*, the larger chela × 2.

* I retain the generic name *Gelasimus*—sanctioned by tradition—to avoid confusion with the distinct group of land crabs known as *Uca*.

The photograph (fig. 11) should be compared with NOBILI's figures. It might conceivably be included under var. *orientalis*, but does not agree well with either.

Length of large propus is in adult male (*a*) much less than that given by ALCOCK, who had before him 300 Indian specimens (ALCOCK's index, large propus l. ÷ C.l. = 3·00).

Ocypoda ceratophthalma (PALLAS, 1772)—A.6, p. 345.

Localities:—Trincomalee, mangrove swamps, two specimens (*b*, *c*); Galle, one specimen (*a*).

Description:—	(*a*) ad. ♀.	(*b*) ad. ♀.	(*c*) ad. ♂.
C.l.	13·50	30·00	36·50
C.b. ÷ C.l.	1·02	1·13	1·07
Projection of eye stalk beyond eye (lower border) ÷ C.l.	0·0	0·10	0·29

C.b. is a straight line uniting points of lateral borders where the serrulate line forks.

In adult female (*b*) the outer band of granules of the ischium of external maxillipeds is somewhat obsolescent, tending, in conjunction with a specimen of *O. platyarsis* in the present collection, to cast doubt upon granulation of this region as a character of specific value.

Ocypoda platyarsis, H. M.-EDW., 1852—A.6, p. 348.

Localities:—Gulf of Manaar, one specimen (*d*); Trincomalee, mangrove swamps, three specimens (*a*, *b*, *c*).

Description:—	(*b*) young ♀.	(*c*) young ♀.	(*d*) adult ♂.
C.l.	15·00	24·00	50·00
C.b. ÷ C.l.	1·27	1·34	1·26
Projection of eye stalk beyond eye (lower bord.) ÷ C.l.	0·10	0·19	—

The distinction between this species and *O. ceratophthalma* in regard to C.b. ÷ C.l. holds, in the present specimens, for both adult and young. In adult male (*d*) the granulation of ischium of external maxillipeds approaches the condition recorded above for an adult female specimen of *O. ceratophthalma*.

Dotilla myctiroides (H. M.-EDW., 1852)—A.6, p. 368.

Localities:—Off Mutwal Island, three specimens; coral reefs, Gulf of Manaar, three specimens; Galle, twenty-three specimens.

Description:—C.l. of an adult male = 8·50.

All the specimens are males except a single immature female from "Coral Reefs, Gulf of Manaar." All the males are mature save one, or perhaps two.

The immature female has seven separate abdominal terga.

Remarks.—Is the striking preponderance of males over females in the collection correlated with a difference in habit, the latter staying at home in the mud?

De Haan's use of the division of the female abdomen into five movable parts only, as a generic character, is not to be considered as contradicted by the present specimen, as the latter is immature (C.l. = 5·50).

Macrophthalmus latreillei (Desmarest), 1822—Plate II., fig. 3, text-fig. 12.

Locality:—Gulf of Manaar, one specimen.

Description:—Ovigerous female. C.l. (front included) = 21·00; C.b. ÷ C.l. = 1·33; front.b. ÷ C.l. = 0·13. (C.b. = straight line uniting points where the granulated line which borders the carapace bends above the bases of walking legs 1. Front.b. is measured across the "neck.")

The carapace, particularly in its grooves, has traces of hair, but there is by no means a hairy covering such as Ortmann describes for *M. laniger*. The lateral teeth of the carapace are both in flatness and in outline more as Ortmann's description and figure of *M. laniger* than as Miers' figure of *M. serratus* (= *latreillei*).

Remarks.—I agree with de Man in uniting *M. polleni*, Hoffmann, 1874, with *M. latreillei*—also with Ortmann in adding *M. serratus*, Adams and White, to the union. I believe further that *M. laniger*, Ortmann, 1894, is not specifically distinct. The main characters in which Ortmann describes *M. laniger* as differing from *M. latreillei* (= *serratus*) are that the former has:—(1) Well-developed hairy covering of carapace; (2) flat, not thorn-like, teeth of lateral margin of carapace; (3) almost straight under border of chela; (4) cheliped of male not very strongly developed.

I have before me a series which makes it difficult to accept these as distinctions of specific value. Another male B.M. specimen (D) is figured (pl. ii., fig. 3).

	A. ♂ (dry). "Challeng." *serratus*. B. Mus. 43–6. Phil. Isds.	C. ♂ (dry). B. M. 83–24. Singapore.	B. ♂ (dry). B. M. 43–6. Phil. Isds.	C′. ♂ (dry). B. M. 83–24. Singapore.	E. ♀ (spirit). Present form. Ceylon.	F. ♂. *laniger* (Ort.'s descr. and figure).
C.l.	41·50	29·00	30·25	27·50	21·00	small
C.hair	absent	much	absent	much	little	much
Arm l. ÷ C.l. . .	0·84	0·74	[0·45]	0·71	0·45	—
P.l. ÷ C.l. . . .	1·37	1·28	[0·65]	1·20	0·62	—
H.l. ÷ C.l. . . .	1·00	0·88	[0·36]	0·82	0·32	—
H.height ÷ C.l. .	0·46	0·47	[0·22]	0·45	0·14	—
F.l. ÷ C.l. . . .	0·54	0·56	[0·31]	0·53	0·35	—
F.l. ÷ H.l. . . .	0·54	0·64	[0·86]	0·64	1·07	—

P.l. = Propus length (under border). H.l. is measured along upper border. Specimen (B) has only one cheliped, and that is a regenerated one.

Examining the above table and the plate one notes that a hairy type of carapace is associated indifferently either with "flat, not thorn-like" carapace-teeth (F), or with acute upturned carapace-teeth (C), or with a somewhat intermediate form (C′). On

the other hand, the character of the marginal teeth of the carapace, the male cheliped measurements and the size of the crab (measured by C.l.), are correlated.

The cheliped differences in the males have the appearance of being growth-changes. The appearance of regenerated cheliped of (B) is suggestive (Pl. II., fig. 3, B). Possibly the differences in the character of the marginal teeth are also growth-changes; one

D. C. A.

Fig. 12. *Macrophthalmus latreillei*—growth stages of male chela.

requires more evidence. It may be noted that in all the males the copulatory appendages appear to be well developed; it would be difficult to say that the smaller specimens are not sexually mature.

I have seen MIERS' small "Challenger" specimens from Japan, referred to by ORTMANN, and put them with the example in the present collection. In one of them the degree of development of hair on the carapace is much as in my specimen. Specimens of this variable species are often found as sub-fossils (HENDERSON, p. 389).

Elamena truncata, A. M.-EDW., 1873—A.6, p. 386.

Locality:—Galle Bay, "From bags hung from buoy," three specimens.

Description:—	(*a*) young ♀.	(*b*) young ♀.	(*c*) adult ♀.
C.l.	5·00	5·25	6·25
C.b. ÷ C.l.	0·95	0·95	1·00

The front is "broadly truncated," but its anterior border cannot be described as "quite straight." BORRADAILE (B.X., p. 682) follows ORTMANN in placing the Hymenosomidæ among the Oxyrhyncha.

Geograpsus crinipes (DANA, 1851)—A.6, p. 396.

Locality:—Galle, in tow-net, one specimen.

Description:—An adult male, C.l. = 32·00. The label gives colours in life:—"Dorsum of carapace very dark purplish-red, ventral surface red (except dactylo-

podites of walking legs—which are nearly white), eye stalks dark purplish-red (as dorsum of carapace), lens black."

The exopodite of external maxilliped bears a slender flagellum—a point which is to be noted, for ALCOCK uses the absence of a flagellum as a generic character, speaking of it in his key as present in *Grapsus* and absent in *Geograpsus*. The two genera are, however, distinguished at once by the very striking fringe of hair on the apposed borders of the coxæ of walking legs 2 and 3—present in *Geograpsus*, absent in *Grapsus*.

Metopograpsus messor (FORSKÅL, 1775)—A.6, p. 397.

Locality :—Trincomalee, four specimens.

Description :—C.l. of an ovigerous female = 16·00.

Sesarma edwardsi, var. **brevipes**, DE MAN, 1889 ('Zool. Jahrb. Syst.,' iv., p. 425).

Locality :—Mouth of a stream near Galle, one specimen.

Description :—An adult male, C.l. = 9·50.

Leiolophus planissimus (HERBST, 1804)—A.6, p. 439.

Locality :—Galle, lagoon, two specimens (small, immature).

Plagusia depressa (FABR.), var. **immaculata**, LAMK., 1818.

Localities :—Cheval Paar, four specimens (*a*, *b*, *c*, *d*); Navakaddu Paar, one specimen (*e*).

Description :—	C.l.	C.b. ÷ C.l.	Post.bord.C. ÷ C.l.	Fronto-orb.b. ÷ C.l.
(*a*) ovigerous ♀ . .	29·00	1·09	0·59	0·66
(*b*) ovigerous ♀ . .	24·25	1·08	0·58	0·70

All come definitely under *P. immaculata* of MIERS' revision ('Ann. Mag. Nat. Hist.,' (5), i., p. 150, 1878). The tubercles are naked in all.

Remarks.—There is some confusion of terminology in regard to this and allied forms. ALCOCK writes "*Plagusia depressa*, var. *squamosa* (HERBST)," which is interpreted by BORRADAILE as "*Plagusia depressa* (HERBST), 1783 [misprinted as 1793], var. *squamosa*, HERBST, 1790." This can hardly be ALCOCK'S meaning, for then (1) *squamosa* would = *depressa* and (2) FABRICIUS had already used *depressa* in a different sense. I take ALCOCK to mean "*Plagusia depressa* (FABR.), 1775, var. *squamosa*, HERBST, 1790," which implies two things: (1) a development of MIERS' views in bringing together under one species the three (*P. depressa* (FABR.), 1775, *P. tuberculata*, LAMARCK, 1818, and *P. immaculata*, LAMARCK, 1818) recognised by the latter in his excellent revision of the Plagusiidæ; (2) a union of the *P. tuberculata* and *P. immaculata* as a single variety within the species so formed. I agree with the first suggestion, but cannot accept the second.

Plagusia depressa (FABRICIUS), 1775, may be divided as follows :—

1. Carapace covered by numerous—often more or less squamiform—tubercles, each bordered by a fringe of short stiff hairs:
   - *a.* Posterior coxal process of 2nd and 3rd walking legs entire . . . . var. *tuberculata.*
   - *b.* Posterior coxal process of 2nd and 3rd walking legs dentate . . . . var. *depressa.*
2. Carapace tubercles more depressed—those on gastric region obsolescent:
   - *a.* Posterior coxal process of 2nd and 3rd walking legs entire . . . . var. *immaculata.*

The few specimens hitherto described show that the above distinctions are average, not absolute, *e.g.*, MIERS' "Challenger" specimen of *depressa* is hardly dentate, and DE MAN describes an example of *immaculata* which has a few hairs on some tubercles. The amount of material is not sufficient to enable one to estimate the exact degree of overlapping.

Additional differentia requiring investigation are:—

1. MIERS points out that carapace is more convex in *immaculata* than in *depressa* or *tuberculata*. This holds in general, but is broken in two instances known to me among the collections of the British Museum, in which *tuberculata* shows approximately same degree of convexity as *immaculata*.

2. Degree of fusion of abdominal terga 3, 4, 5 and 6. I have before me only 4 males (1 *immaculata* + 2 *depressa* + 1 *tuberculata*), which suggest that the tendency for such fusion may be found to be greater in *depressa* and *immaculata* than in *tuberculata*.

3. Shape of abdomen.

4. Size of carapace—*immaculata* being smaller than the others.

Of the above, the first at least is of value—possibly all are so. I retain for the varieties the names used by MIERS, entirely avoiding *squamosa*. If used, the latter should apply to the *tuberculata* series only, but it has the grave disadvantage of having been used by HERBST to denote in the text a form with entire coxal process, and in his figure one with coxal process dentate.

Palicus jukesi (WHITE, 1847)—A.6, p. 451—Plate I., fig. 12.

Locality:—Coral reefs, Gulf of Manaar, one specimen.

Description:—An adult male. C.l. = 14·25 (frontal lobes included). C.b. ÷ C.l. = 1·11.

Remarks.—This specimen confirms CALMAN'S inclusion of *Cymopolia carinipes*, PAULSON, 1875, in the synonymy of the species—for, while answering to ALCOCK'S description, it has, instead of the sub-hepatic tubercle described by CALMAN for his

Torres Straits specimen, a transverse row of four granules (*cf.* PAULSON's ridge), from outer end of which a row of granules runs backward for a short distance parallel to the lateral margin of the carapace. With my figure should be compared that of Dr. CALMAN (C., pl. i., fig. 10).

I follow ALCOCK in emphasising the probably catometope affinities of the genus *Palicus*. On this matter see CALMAN, p. 29.

Palicus serripes (ALCOCK and AND., 1894)—A.6, p. 454; A.Invest., pl. lxvii., fig. 1.

Localities:—Trincomalee, one specimen (*a*); Gulf of Manaar, deep water, one specimen (*b*).

Description:—(*a*) ovigerous ♀ . . C.l. = 10·50; C.b. : C.l. = 1·10
(*b*) ovigerous ♀ . . C.l. = 9·00; C.b. ÷ C.l. = 1·11

NOTE.—In the above pages 196 species are named. There remain 12 undetermined forms in the collection, making 208 in all. Of these 12, one is an Oxystome, one an Oxyrhynch, seven are Xanthids, one is a Portunid, and the remaining two are Catametopes.

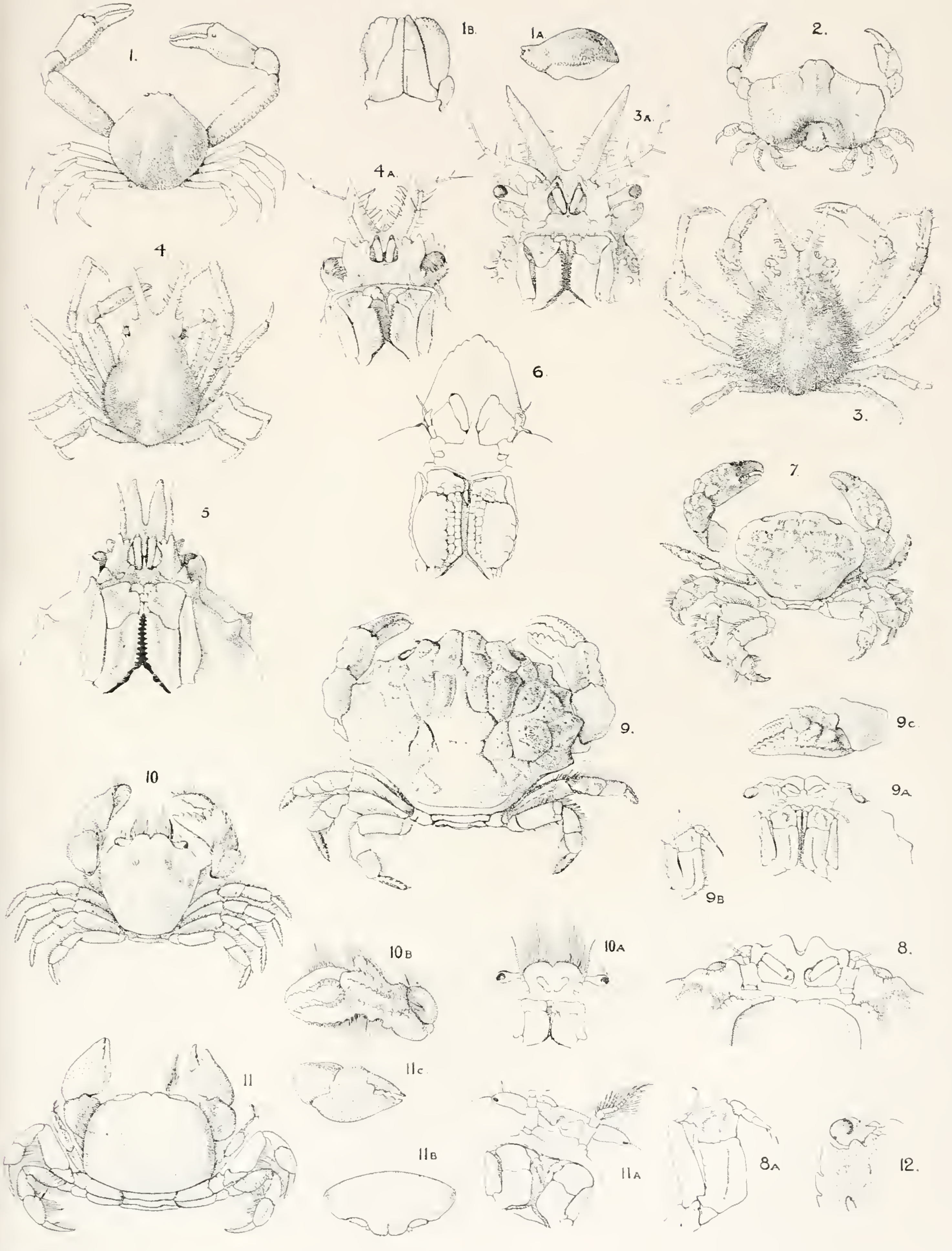
EXPLANATION OF PLATES.

PLATE I.

Fig. 1. *Philyra adamsi*, Bell. ♂. (Bell's "type"-specimen refigured.) × 2.
a, hepatic facet, &c. × 2; *b*, buccal region with external maxilliped of one side removed. × 5.
" 2. *Tlos havelocki*, n. sp. × 3.
" 3. *Halimus pehleri*, n. sp. × 2.
a, ventral view of anterior region. × 5.
" 4. *Halimus irami*, n. sp. × 2½.
a, ventral view of anterior region. × 5.
" 5. *Doclea alcocki*, n. sp., ♀, ventral view of anterior region. × 1½.
" 6. *Cryptopodia pan*, n. sp., ventral view of anterior region. × 4.
" 7. *Zozymus gemmula*, var. *ceylonica*, nov. × 2.
" 8. *Demania splendida*, n. gen. et sp., ventral view of anterior region. × 2.
a, external maxilliped. × 2.
" 9. *Euxanthus herdmani*, n. sp. × 1½.
a, ventral view of anterior region. × 1½; outer surface of wrist, hand and fingers. × 1½.
" 10. *Calmania prima*, n. sp. × 3.
a, ventral view of anterior region. × 2. *b*, outer surface of hand. × 3.
" 11. *Mertonia lanka*, n. sp. × 4.
a, ventral view of anterior region. × 8. *b*, anterior view. × 4. *c*, outer surface of hand. × 4.
" 12. *Palicus jukesi* (White), sub-hepatic region. × 2.

PLATE II.

Fig. 1. *Demania splendida*, dorsal and ventral views. Nat. size.
" 2. *Doclea alcocki*, dorsal and ventral views. × ¾.
" 3. *Macrophthalmus latreillei* (Desm.)—A–E, five specimens illustrating the characters given in the text. B shows regenerated cheliped; opposite surface in small figure alongside.



G. M. W. del.

Fig. 1.

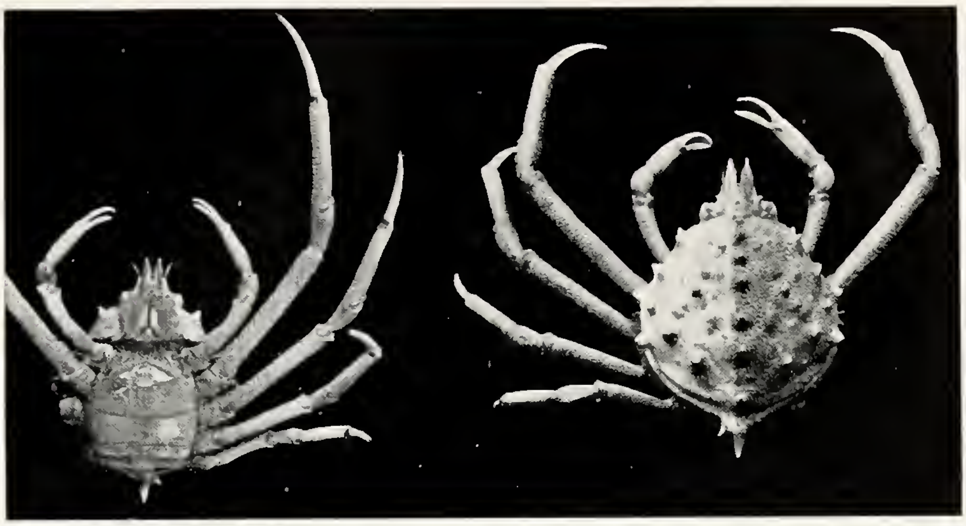


Fig 2.

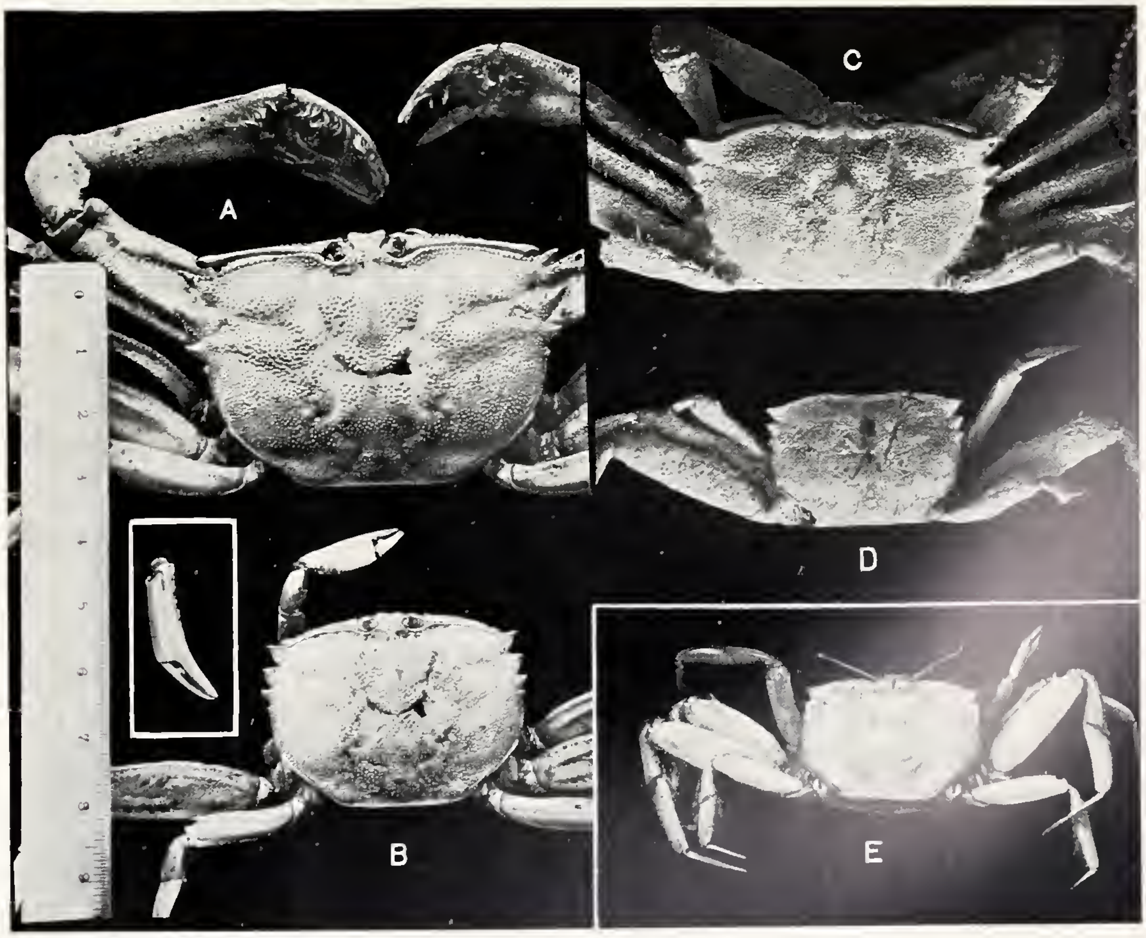


Fig. 3.

DISCUSSION OF FAUNISTIC RESULTS.

BY

W. A. HERDMAN, F.R.S.

[WITH TWO PLATES AND TEXT-FIGURES.]

THE preceding forty Supplementary Reports, along with the four upon Parasites, have made known 2615 species of marine animals from the coasts of Ceylon. Of these, 575 species are described as new to science, and have required the formation of 65 new genera and three new families. The distribution of these species in the chief groups of animals is shown in the following table :—

Group.	Number of species.	New species.	New genera.
Foraminifera . . .	130	3	—
Sponges	146	77	11
Hydroids	43	13	1
Medusæ	29	12	—
Alcyonaria	120	47	2
Antipatharia . . .	13	10	—
Actiniaria	14	?	—
Corals (Solitary and Reef)	51	5	2
Echinodermata . .	109	8	1
Platyelmia	74	65	20
Nematoda	7	3	—
Gephyrea	10	1	1
Polychæta	112	36	2
Polyzoa	116	16	—
Cirripedia	11	1	—
Copepoda	289	80	12
Ostracoda	77	35	—
Amphipoda . . .	85	37	6
Carried forward	1436	449	58

Group.	Number of species.	New species.	New genera.
Brought forward	1436	449	58
Isopoda	34	14	3
Cumacea	16	9	1
Leptostraca, Stomatopoda, and Schizopoda	18	2	—
Macrura	53	3	—
Anomura	48	2	—
Brachyura	208	15	3
Pantopoda	2	2	—
Hemiptera	1	1	—
Polyplacophora . .	9	5	—
Molluscan Shells . .	530	10 (?)	—
Opisthobranchia . .	50	16	—
Cephalopoda . . .	20	2	—
Tunicata	66	44	—
Cephalochorda . .	7	—	—
Pisces	117	1	—
Totals . . .	2615	575	65

The majority of the previously known species are new records for the Ceylon fauna and a large number of them are new to the fauna of the Indian Ocean, and, consequently, the Reports have added considerably to the recorded distribution of many of the older species. It is almost impossible to get exact numbers in such a case, but it is probably fairly correct to say that 1500 species have been added to the

Ceylon list and about 900 to that of the Indian Ocean. Such information, although, perhaps, as uninteresting as the description of new species, is of real importance in science, as it is impossible to draw conclusions as to geographical distribution, and the origin and past history of faunas, until we have a detailed knowledge of the animals now present in many different localities.

In comparing with other seas, we find that about 250 of our species* extend into the Malay region and 300 on into the Pacific. At least 240 are known from the Red Sea and 130 from the Mediterranean. About 280 species extend southwards to the Australian coasts, and a few are found elsewhere in southern latitudes. Finally, 90 Ceylon species are found also in the West Indian region, and may indicate a closer connection by sea in a former period than exists at the present day. This interesting relation between these two far-distant regions—the East and the West Indies—has been pointed out by several writers, and in 1899, ALCOCK† published an interesting chart (after E. KOKEN) showing a direct connection by means of a great inland basin stretching east and west from the Gulf of Mexico to the Arabian Sea. This indicated the supposed relations of land and water in Tertiary times, and was put forward by Dr. ALCOCK to elucidate the theory he advanced as to the origin of a considerable part of the Fish fauna of India from a Tertiary extended Mediterranean stretching across the present mid-Atlantic to the West Indies.

Fig. 1. Map to show the equatorial seas and the relative positions of: I. Gulf of Manaar, II. Mergui Archipelago, and III. the Maldives.

Restricting our attention now to the northern part of the Indian Ocean, there are three recent series of faunistic explorations with which we may compare our results, viz., (1) the Reports on the Mergui Archipelago, off the coast of Lower Burma (see

* Possibly a good many more. These numbers are all minimum estimates.

† Descriptive Catalogue of Indian Deep Sea Fishes in the Indian Museum, Calcutta.

'Journ. Linnean Soc., Zool.,' vols. xxi. and xxii.), (2) the series of Reports and "Illustrations" issued from the Calcutta Museum as the result of work by Colonel ALCOCK and others in the "Investigator," and (3) Mr. STANLEY GARDINER'S series dealing with "The Fauna and Geography of the Maldive and Laccadive Archipelagoes." The map (fig. 1) will serve to recall relative positions and distances.

The Mergui marine fauna is, as might be expected, not unlike that of Ceylon, but differs in the details of the species that occur. It is, however, if we may judge from the published records, not so rich a fauna, as the following summary will show—using only those groups which are common to the two reports. The predominance of Actinozoa, in the case of Mergui, is due to the large number of species of Corals described by Professor MARTIN DUNCAN. The other groups of fixed organisms—Sponges, Hydroids, Alcyonaria and Polyzoa—show markedly in favour of Ceylon.

	Sponges.	Hydroida.	Alcyonaria.	Actinozoa.	Echinodermata.	Gephyrea.	Polychæta.	Polyzoa.	Stomatopoda.	Macrura.	Anomura.	Brachyura.	Marine shells.	Totals.
Mergui.	30	6	23	86	48	4	5	21	4	19	26	116	328	716
Ceylon.	146	43	120	78	109	10	112	116	12	53	48	208	530	1585

As an indication that the fauna of the Indian Ocean is gradually becoming known, in, at least, some groups, it may be noted that in Dr. DE MAN'S account of the Mergui Podophthalmata (1888) out of 166 species, 38 (about 23 per cent.) were new to science, while 18 years later, in the present report, out of the much larger number (321) of Ceylon Podophthalmata, only 22 (less than 7 per cent.) were previously unknown. In Brachyura, 39 species (nearly $\frac{1}{5}$) are common to the two lists.

Colonel ALCOCK'S magnificent series of monographs and the accompanying fasciculi of "Illustrations," have done much to elucidate the fauna of the northern part of the Indian Ocean, but they deal largely with deep-water forms, and I find it difficult to make any comparison between my restricted, but, perhaps, more intensive, study of a small shallow-water area (the Gulf of Manaar) and his extended gleanings all over the three seas of India. Perhaps the most important conclusion to be drawn is the extreme richness of the fauna, since so little is common to the two series of results. Some groups have not yet appeared in the "Investigator" series, but even in the case of those that have been monographed, the shallow waters of Ceylon have here and there added something to the list. These reports cannot be compared in number of novelties with the "Investigator" monographs, but they may be regarded as in some respects supplementing them.

The comparison with the Maldive fauna ought to be more satisfactory and interesting:—first, because STANLEY GARDINER'S reports are almost as recent as

these, and are therefore presumably done on very much the same lines, so as to be fairly comparable with ours; and, secondly, because the Maldives are a group of Coral-formed oceanic islands in contrast to Ceylon, which is continental and geologically a part of India. The comparison between a shallow-water (under 100 fathoms), continental-coast fauna and that of a group of oceanic coral islands, only, on the average, some 400 miles apart, in the same latitudes and the same sea, but separated by deep water, ought to be instructive.

The following table shows the number of species in the chief groups which are recorded in both series of Reports :—

	Hydroida.	Medusæ.	Alcyonaria.	Actinozoa.	Echinodermata.	Platyelmia.	Gephyrea.	Cirripedia.	Copepoda.	Amphipoda.	Isopoda.	Stomatopoda.	Macrura.	Anomura.	Brachyura.	Mollusca.	Cephalochorda.	Pisces.	Totals.
Maldives . . .	23	44	39	112	49	28	25	16	120	19	14	6	79	34	189	431	4	65	1297
Ceylon . . .	43	29	120	78	109	74	10	11	289	85	34	12	53	48	208	530	7	117	1857

There are evidently marked differences here, and some of them at least seem susceptible of explanation. A group of oceanic coral islands must clearly have been populated from some of the surrounding older continental coasts,* and the nearest of these to the Maldives are Ceylon and the southern end of India, some three to five hundred miles distant.† There are two dominant factors that will play an important part in determining which animals from the neighbouring continent will form part of the new population, viz :—(1) The means of transport possessed by the animals either in the adult or the larval condition, and (2) whether or not the conditions existing on the island are sufficiently favourable to the migrating animal on its arrival either as an adult or a larva.

Looking at the table we find that the total number of animals is much greater in the recorded Ceylon fauna than in that of the Maldives, but that in certain groups —the Medusæ, Actinozoa, Gephyrea, Cirripedia, and Macrura—the Maldivian numbers are the greater; while in other groups—such as Hydroida, Alcyonaria, Echinodermata, Platyelmia, Copepoda, Amphipoda. Isopoda, and Mollusca—the Ceylon list markedly predominates.

Oceanic or pelagic groups, as would be expected, and coastal animals of active

* We may assume that even if Mr. Gardiner's view is correct, that the Maldives are based upon an old continental platform cut down by currents to a depth of some 2000 fathoms, none of the original continental animals have lived on to appear amongst the inhabitants of the coral reefs.

† Of course, some species may have come from the much more distant African coast.

habit, possessing the necessary means of transport in the adult condition, are well represented in the Maldive fauna. For example, Fishes, Medusæ, and Chætognatha are all fairly abundant. The Cirripedia also, some of which are almost cosmopolitan in their distribution on the high seas, are more numerous than in Ceylon. The Copepoda might be expected to bulk larger than they do. The pelagic and more active forms are, however, present, and the deficiency is in the bottom-living species, many of which are associated with Sponges, Tunicates, and other fixed colonies which are probably much more abundant at Ceylon than in the Maldives. The high number in the case of Actinozoa is due to species of Madreporaria which are, of course, abundant in a Coral archipelago, and the species of which were especially studied by Mr. STANLEY GARDINER. In the case of Macrura the 79 species includes 76 Alpheidæ, and the species of *Alpheus* being closely associated in habitat with Corals would naturally be obtained in abundance amongst the reefs.

Turning now to the groups of animals which are more abundant at Ceylon, we find that it is the fixed and the more or less sedentary, bottom-living forms that are poorly represented in the Maldivian fauna—*e.g.*, Hydroida, Alcyonaria, Echinoderma, and Mollusca. I should expect this result to apply also to Sponges, Polyzoa, and Tunicata, and I have little doubt that it does, but these groups in the case of the Maldivian fauna have not yet been reported on. Most of these groups are dependent for dispersal upon minute, feeble, and short-lived embryos or larvæ to which 400 miles of open sea may be a formidable obstacle. In marked contrast to some of these groups there is the case of the Brachyura, where the numbers in the two faunas (Maldives 189 and Ceylon 208) are not very different. The probable explanation is that the larvæ of the crabs are powerful, locomotory, comparatively long-lived animals which are frequently taken in the tow-net in the open sea, and are therefore much better fitted to survive the journey from the continental coast. The most feebly represented of Crustacean groups are the Amphipoda and Isopoda, and I would suggest that the explanation is to be found in the unsuitability of their young stages for distribution to oceanic islands. Those that do cross in safety are probably carried accidentally on larger objects. It may conceivably be easier for a shallow-water species, which neither in the adult nor in larval life is adapted to a prolonged pelagic existence, to spread in the course of ages from India to Australia along the stepping-stones of Malaysia than to cross the stretch of open sea from Ceylon to the Maldives.

There is, however, not only the numerical but also the specific constitution of the two faunas to be considered, and, undoubtedly, many species are common to the Maldives and Ceylon. Probably all the Corals collected in the Gulf of Manaar have been recorded in Mr. STANLEY GARDINER'S reports, and nearly all their associated Alpheidæ. The Foraminifera seem to be very much the same in the two localities, at corresponding depths. Out of 131 species found at Ceylon, 68 occur in CHAPMAN'S list from the Laccadives, and the latter collection was mainly, if not wholly, a deep-

water one. An analysis of the recorded Echinoderms gives us the following result :—

Crinoidea . .	10 Maldivian species,	16 Ceylon species,	5 in common	
Asteroidea . .	13 ,, ,,	25 ,, ,,	8 ,,	
Ophiuroidea .	12 ,, ,,	13 ,, ,,	5 ,,	
Echinoidea . .	15 ,, ,,	28 ,, ,,	12 ,,	

In the Amphipoda 11 species out of the 19 found in the Maldives occur also in Ceylon. Even in the Isopoda a few species, such as *Cirolana sulcaticauda*, *Lanocira gardineri*, and *Cymodoce inornata*, are common to both faunas. Mr. LAURIE considers that the Ceylon crabs show a marked resemblance to those of the Maldives, over 70 of the species being identical.

In some groups little relationship is shown. In the Nudibranchiata only one Ceylon species extends to the Maldives; amongst the Hydroids there are two, but in addition we find several pairs of representative or closely allied species which might by some be regarded as identical forms. The Maldive Cephalopoda, according to Dr. HOYLE, exhibit a "remarkable likeness" to those of Ceylon, and several species are identical. Mr. BROWNE, on the other hand, calls attention to the dissimilarity of the Medusæ, but we must remember that two successive collections of Medusæ (GARDINER'S and AGASSIZ'S) made in the Maldives were also very dissimilar.

Confining our attention now to the Ceylon marine fauna, we may conveniently divide our records into three sets of localities :—

1. Trincomalee and the north-east coast (Stations XX. to XXXI.*).
2. Galle and the south end of the island up to Colombo (Stations XXXII. to XLVI.).
3. The Gulf of Manaar and around Adam's Bridge, from Colombo to Palk Bay (Stations I. to XIX. and XLVII. to LXIX.).

Of these three regions of the coast, the first two have deeper water and a more varied fauna than is found in the pearl-bank region of the Gulf of Manaar. But, on the other hand, we have more stations in the third district, where much more time was spent and where the fauna, on the pearl banks, was consequently studied much more closely than elsewhere. The following table gives the number of species in each group of animals found in each of the three districts :—

* See "Narrative," in Part I. (1903), for details as to the Stations.

Group.	Trincomalee.	Galle.	Gulf of Manaar.	Group.	Trincomalee.	Galle.	Gulf of Manaar.
Foraminifera . . .	11	15	130	Brought forward	133	408	1147
Sponges	11	65	105				
Hydroids	1	18	38	Isopoda.	1	10	28
Medusæ.	1	13	22	Cumacea	—	1	15
Alcyonaria. . . .	15	29	91	Leptostraca, Stomatopoda, and Schizopoda	2	1	17
Antipatharia . . .	4	6	5	Macrura	4	17	43
Actiniaria	3	5	7	Anomura	9	22	36
Corals (Solitary and Reef).	16	33	35	Brachyura	35	60	170
Echinodermata . .	19	45	74	Pantopoda. . . .	—	1	2
Platyelmia. . . .	1	4	67	Hemiptera. . . .	—	1	1
Nematoda	—	—	7	Polyplacophora . .	1	3	7
Gephyrea	2	5	8	Molluscan Shells. .	175	145	357
Polychæta	4	28	81	Opisthobranchia . .	3	6	44
Polyzoa.	9	50	107	Cephalopoda . . .	1	3	18
Cirripedia	1	2	13	Tunicata	7	14	59
Copepoda	18	63	214	Cephalochorda . .	—	2	4
Ostracoda	1	4	67	Pisces	5	23	95
Amphipoda . . .	16	23	76				
Carried forward	133	408	1147	Totals . . .	376	717	2043

The great majority of the shallow-water forms have spread all round the island. To take the pearl oyster as an index, while its home may be said to be the Gulf of Manaar, it occurs in fair quantity in shallow water at Trincomalee, and sparingly at Galle. In regard to the rarer and finer things, such as Solitary Corals, branched Alcyonaria, Antipatharia, and some Echinoderms, Crustacea and Mollusca, I am inclined to think the distribution is a question of depth rather than locality. They have been found at Trincomalee and off Galle where rather deeper water was obtained, but probably occur also in the depths outside the pearl bank plateau in the Gulf of Manaar.

Let us now pass the various groups in review so as to ascertain the general impression given by the fauna in each case; and I desire here to acknowledge that, while I am alone responsible for any opinions that are not quoted from others, I am indebted directly or indirectly to my friends the authors of the special Reports for most of the facts upon which these opinions are founded.

The FORAMINIFERA figure largely in the deposits round the Ceylon coast. Two extreme examples may be given. At the 100-fathom line, south of Galle, the bottom seems to be practically composed of masses of the new species *Ramulina herdmani*, DAKIN; and at several points in the Gulf of Manaar up to 40 per cent. of the deposit is formed of *Heterostegina depressa*. Other species, such as *Amphistegina lessoni*, *Orbitolites marginalis*, and *Alveolina melo*, are also so abundant that to the eye the deposit, when it comes up in the dredge, appears to be formed mainly of Foraminifera. *Polytrema miniaceum* is also of very frequent occurrence, and grows to a large size.

But beyond this abundance of certain species there is no special feature to be noted. The collection is an ordinary assemblage of shallow-water tropical forms, including a few rare species and three new to science—the most remarkable of which is the *Ramulina* found in such abundance in deep water off Galle. Most of the species are new records to Ceylon, and 50 are new to the Indian Ocean. Many of them have a wide distribution in other seas, and at least 57 species are common to Ceylon and the West Indies.

Fig. 2. *Ramulina herdmani*, DAKIN. Nat. size.

The collection of SPONGES is a very large one, containing about 150 species, nearly 80 of which are new to science. Moreover, the individuals of some of these species are numerous, so that sponges bulk large in the fauna, especially in the Gulf of Manaar. The Calcarea are few and small and the Hexactinellida not represented, but the Tetractinellida, the Monaxonellida, and the Euceratosa present a rich and varied assemblage of forms. Some of the species are cosmopolitan, many are common Indo-Pacific forms; only a few extend to the Red Sea, a few more to the Mediterranean, and as many to the North Atlantic (Azores and even the British seas), half-a-dozen are represented in the West Indies, and a dozen extend eastwards through the Malay Archipelago. But much the closest affinity is shown with the fauna of Australia, as no less than 30 of the species in our collection are found also on the Australian coast. Adding to this the other known Ceylonese species, Professor DENDY finds that 47 in all out of the 75 species of sponges whose range is known to extend beyond Ceylon seas are found in the Indo-Australian region. About two-thirds of the total number of species are, however, peculiar to the Ceylon area which Professor DENDY speaks of as "an extremely rich centre of sponge distribution." Some of the most notable species from the Gulf of Manaar are shown on Plate II., figs. 1 to 4.

The Ceylon MEDUSÆ comprise 29 species, 12 of which were new to science. They are represented sparingly in all the other seas of the world, including the West Indies, and rather more fully in the Malay archipelago. But there is no indication

of marked affinity with any other fauna. In fact, the differences are more evident than the resemblances. Even in the case of two such neighbouring localities as the Maldives and Ceylon, Mr. E. T. BROWNE, after considering the figures, writes: "the Medusoid fauna of Ceylon is quite distinct from that of the Maldives." But the fact that the genera and species of GARDINER'S and AGASSIZ'S successive expeditions to the Maldives "were quite distinct," and that there is a well-marked difference between the two collections "which is quite as great as if they had come from localities a thousand miles apart" (BROWNE) shows that we must not attach too much importance to such differences. Seasons and methods of collecting must be taken into account, and we have probably still much to learn in regard to each of these faunas.

The HYDROIDA are fairly abundant at Ceylon, and some of them are of large size (see Plate II., figs. 5 and 6). Outside the Indian Ocean the affinities of the Ceylon forms are distinctly with those of Australian seas—out of 43 species, 11 extend to Australia, and only nine of the other species are found beyond the Ceylon seas; four of these occur in the West Indies, and only one in the Mediterranean.

The ALCYONARIA form a rich collection, dealt with in three reports (Nos. XIX., XX., and XXVIII.). Miss PRATT points out the similarity with the Maldive fauna, nine species of the fleshy forms, out of 17, being common to the two districts; but Professor ARTHUR THOMSON, dealing with the Gorgonoid, Pennatulid, and other non-fleshy forms, lays stress upon the great difference between the present collection and those from Zanzibar (CROSSLAND), Maldives (GARDINER), New Britain (WILLEY), and the deeper waters of the Indian Ocean (ALCOCK). I believe this merely indicates that the Alcyonarian fauna of these regions is so rich that we are still far from having completed the survey. Each new expedition brings in an abundant harvest, and in our present state of knowledge it is probably more profitable to base any tentative conclusions upon resemblances in the fauna rather than upon differences which may merely be due to negative evidence.

Many of the species are familiar Indo-Pacific forms, a few are represented in the Malay region; but perhaps the closest affinity is with the Red Sea fauna, on the one hand, and with that of Australian seas on the other. As in the case of so many other groups, at least one species is represented in the West Indies.

CORALS are, of course, exceedingly abundant round the coast of Ceylon. The reef-building forms were not specially collected and have not been reported on, but over 30 common species have been brought home. There are in the collection about 21 species of Solitary Corals, five of which are described as new, along with two new genera—*Rhodocyathus* and *Cyathotrochus*.

The ACTINIARIA, although not reported on, have been examined by Mr. SOUTHWELL, who finds about 14 species, of which several are probably undescribed forms. A beautiful green, colonial form, *Zoanthus shackletoni*, is very abundant on the reef at Galle and in some parts of the Gulf of Manaar. A species of *Palythoa* (*P. tuber-*

culosa) is also common at Galle. But, perhaps, the most noteworthy form is the remarkable, free, sand-encrusted anemone *Sphenopus marsupialis*, which is apparently abundant at several localities in the Gulf of Manaar.

ANTIPATHARIA are amongst the most striking forms brought up from the deeper water outside the pearl banks or at Trincomalee and Galle. Most of the smaller colonies obtained were new species; but the finest belonged to the well-known *Antipathes abies*. Several of our Ceylon species occur in the Maldives.

The ECHINODERMATA are an ordinary Indo-Pacific series presenting a few rarities, a few novelties, and some extensions of distribution, but no other notable features. It may be of interest to show the numbers of the orders separately in the case of several allied Indian Ocean faunas:—

	Mergui.	Maldives.	THURSTON (Manaar).	Ceylon collection.	ALCOCK (deep-sea).
Crinoidea	6	10	4	13	(?) few
Asteroidea.	9	13	18	25	60
Ophiuroidea	13	12	12	14	56
Echinoidea	6	15	21	28	(?) 60
Holothuroidea	14	—	10	30	(?) 20

Probably, on the whole, the Echinodermata of Ceylon present most affinity with those of the Malay region and of the Pacific, but they also show resemblances to the Australian fauna.

In turning to the VERMES, it is found impracticable to institute any comparisons with other faunas in the case of the lower parasitic groups, since, in the first place, from the nature of our enquiry on the Ceylon expedition it was clearly of importance to collect and identify such forms as Cestode, Trematode, and Nematode parasites which are very usually neglected by the general zoologist; and, in the second place, these worms seem in many cases to be confined to particular hosts, and their distribution will therefore be determined by that of the Fishes and Molluscs they infest. Consequently the fact that 54 Cestoda are recorded from Ceylon seas and none from the Mergui or from the Maldives, must not be taken to indicate that parasitic worms are more abundant in the one locality than in the others. That these Platyelmian groups yielded a very large proportion of new species, no less than 17 new genera and one new family, is due first to our comparative ignorance of the fish Cestodes and Trematodes from tropical waters, and, secondly, to the special attention paid to them during our expedition on account of their possible bearing upon the problem of pearl production.

The 10 species of GEPHYREA, one new and the type of a new genus, are nearly all additional records for Ceylon, and half of them are new to the Indian Ocean. Their affinities seem mainly with those of the Malaysian seas to the East.

The POLYCHÆTA comprise over 112 species, of which at least 36 are new to science. In regard to these higher worms, Dr. WILLEY writes that the Polychæte fauna of Ceylon bears a circumtropical stamp in contrast, for example, with the northern and the southern faunas: a good many of the species are identical with Philippine forms. The occurrence of a species of *Grymæa* (a characteristic Scandinavian genus) is rather singular. Perhaps the most remarkable form of all is the new *Thalenessa stylolepis* obtained from coral masses in the Gulf of Manaar.

The POLYZOA form a large collection with a comparatively small proportion of novelties, 16 species out of 116. Some are cosmopolitan, and a considerable number extend into other seas, no less than 19 being British species. The chief indication of affinity is, however, with the Australian fauna, as 32 species are in common. Seven species are West Indian forms, and at least 85 are new records to the Indian Ocean, and probably about 100 are new to Ceylon.

Minute CRUSTACEA, such as Copepods and Ostracods, swarm both on the surface and in the deposits at the bottom.

The COPEPODA fauna is enormous, and the collection contained many novelties. Nearly 300 species (289 have been identified) were collected; 80 of these are new to science, and 12 new genera have been required. Nearly all the species found were additions to the known fauna of Ceylon and of the Indian Ocean. The majority (over two-thirds) of the species are from the Gulf of Manaar, about one-fourth are from Galle, and a few only from Trincomalee.

It is difficult to institute any comparisons with other faunas, as in most seas the more minute Copepods are still very imperfectly known. There was no report on Copepoda in the case of the Mergui Archipelago, and in respect of some expeditions it is known that while free-swimming Copepoda were collected in tow-nets from the surface and intermediate waters, no steps were taken to explore the very abundant fauna living in the bottom-deposits or in and upon the dredged larger animals, or to secure the parasitic forms attached to fish. In the case of the Gulf of Manaar these two last faunas yielded a rich harvest of unknown forms.

The results brought out by our records that the Ceylon Copepod fauna shows most affinity with that of the Red Sea and of the Mediterranean is largely due to the fact that we have a better knowledge of these regions than, for example, we have in the case of the Malaysian or Australian seas. Dr. NORRIS WOLFENDEN* has recently remarked upon the very striking difference in the Copepod fauna between Ceylon and the Maldives. This difference, however, seems to be chiefly confined to the littoral Harpacticidæ, which are only represented by five or six species from the Maldives, while in the Ceylon collections they are very abundant.

In the case of the Ceylon OSTRACODA, out of 77 species 35 were new to science, and nearly all were obtained from the Gulf of Manaar. The majority of the species are new to the Ceylon fauna and that of the Indian Ocean. There is no clear indication

* "Fauna and Geogr., Maldive," &c., vol. II., suppl., 1, p. 989.

of affinity with other regions. The CIRRIPEDIA are a somewhat cosmopolitan group, but our Ceylon assemblage shows some affinity with the Red Sea and the Australian faunas.

The AMPHIPODA and ISOPODA were both large collections containing a number of new forms. The individual animals in both were of small size compared with those from temperate and polar seas. In the Amphipoda 85 species gave 37 new to science, requiring the formation of six new genera. A few of the species extend to the Red Sea, the West Indies, the Malay Archipelago, and the Pacific, seven are found in the Australian fauna, and ten in the Mediterranean. In the case of the Isopoda, out of 34 species 14 proved to be new, requiring three new genera and two new families. Here, also, there is indication of Australian affinities, and two species extend to the West Indies.

The CUMACEA, being a comparatively unknown group, are all new records for the Indian Ocean, and out of the 16 species nine are new and one has required a new genus. We do not know enough of the distribution in this case, or in that of the STOMATOPODA and SCHIZOPODA, to make comparisons with other seas.

In the MACRURA, out of 53 species, three of which are new, a large proportion, 24, extend into the Pacific, 10 are common to the Malaysian fauna, and 10 also reach the Australian seas, nine are found in the Atlantic, four in the Red Sea, three in the Mediterranean, and one in the West Indies.

The ANOMURA, as a group, have, to the collector, the appearance of being very abundant, but that is due chiefly to great numbers of a few common species. At Galle, and at Trincomalee, ten times the present collection might easily have been made without adding to the number of species. Out of 48 species collected only two are new, and they present no features of special interest. ALCOCK has pointed out that the littoral Paguridæ of the Maldives and India are Indo-Pacific forms, while the sub-littoral forms of Indian seas are most closely related to those of the West Indies.

The BRACHYURA form a very large and interesting assemblage, in which only a comparatively small proportion, 15 out of 208 species, have proved to be unknown, but three of these are so remarkable as to require new genera. About 60 per cent. of the species are new to the Ceylon fauna, and 35 per cent. extend to the Maldives.

The PANTOPODA and HEMIPTERA both contain new forms that seem to be common at Ceylon, but call for no further remark.

The MOLLUSCA are an ordinary Indo-Pacific assemblage, most of which have been made known in the past from shell collections. The chief novelties are naturally in those divisions of the group which have not been studied by conchologists. The Nudibranchs present us with at least nine new species in 30 collected, and, in addition, there are some small Eolids and Dotos undetermined that show, at least, that these families are not so rare as was supposed in tropical seas. The Opisthobranchs, as a whole, show some affinity with Red Sea and Mediterranean forms, but still more with the Pacific and Australian faunas. Two new species of Pelecypoda,

living with the *Aspidosiphon* in the basal cavities of Solitary Corals, are described by BOURNE under the new genus *Jousseaumia* (Report XXXVII.). The profusion of young Octopods, of undetermined species, on the pearl banks in the Gulf of Manaar was a notable feature during our exploration. Some of the same forms occur at the Maldives.

The TUNICATA are not numerous (66 species), although some of the commoner forms are so abundant that the group bulks large in the general fauna; 44 species are new to science, and nearly all the species (about 60) are new records for the Ceylon fauna. Calcareous and sandy genera, such as *Leptoclinum*, *Rhabdocynthia*, and *Psammaplidium*, are especially abundant and large. *Ecteinascidia*, *Rhodosoma*, *Hypurgon*, and the Polystyelidæ are other noteworthy forms. As is usual in tropical seas, the Cynthiidæ and Styelidæ are especially abundant, and the Ascidiidæ and Botryllidæ are few and of small size. Very few Molgulidæ were found, but several other kinds of Simple Ascidians belonging to other families have sandy coverings so as to look superficially like species of *Molgula*. *Pyrosoma*, though no doubt sometimes present, was not seen; and the Thaliacea were not especially abundant. The commonest genera are *Polycarpa* amongst the Simple Ascidians and *Leptoclinum* in the Compound forms. Although most of the species are peculiar to Ceylon or the Indian Ocean, there are allied forms elsewhere, and it may be said that the fauna shows affinity with that of the Malay Archipelago and that of the Australian seas.

Seven species of CEPHALOCHORDA were obtained, four of which are new to the Ceylon fauna. The collection of FISHES has added considerably to the Ceylon list, but does not call for any special remarks. Adding THURSTON's list to our own, the total number of fishes recorded from the Gulf of Manaar is over 226, but I do not doubt that even that could be largely added to by further work. The Maldive list is 57 named species, but of these only 17 extend to Ceylon. Thus the percentage of Ceylon fishes recorded from the Maldives is small. The Pleuronectidæ are well represented in both faunas, but there are no species common to the two lists.

On the whole it seems probable from this survey of the groups that the Ceylon marine fauna is more closely related to that of the Malay region and Australia than to that of the Maldives or the Red Sea.

THE FAUNISTIC CHARACTERS OF THE PEARL BANKS.

The physical and the leading biological characters of the individual paars were given in the section entitled "Description of the Pearl Oyster Banks of the Gulf of Manaar," in Part I. at p. 99, and it is only necessary now to point out the general faunistic features of the region as a whole. It will be remembered that it is a shallow plateau, lying for the most part between the contours of 5 and 10 fathoms, and having on the whole a sandy bottom. Where the ground is hard it is a modern calcrete formed by the cementing together of sand and shells, and where the sand is not

derived from the disintegration of the granitoid rocks of Ceylon it is mainly Foraminifera and shell fragments. The large amount of a few species of Foraminifera in some deposits is a notable feature, which has been already discussed above. In some parts, as on the South Cheval, balls of *Lithothamnion fruticulosum*, large and small, are very abundant and are useful as cultch for the pearl oyster.

Sponges are a very dominant group, and probably exercise considerable influence upon the welfare of the oyster beds. The most important in this connection is *Cliona margaritiferæ*, the ravages of which have been described and figured in previous sections of this report. Other characteristic forms are the large black *Spongionella nigra* and the four species of Sponge shown on Plate II. Fig. 1 is the huge crater-like *Petrosia testudinaria* which occurs on the Cheval and especially on the Periya Paar. Fig. 2 shows the two characteristic forms, the cup-like and the flabellate, of *Phakellia donnani*, a brick-red Sponge found in great abundance on many parts of the pearl banks, but especially on the Modragams, the Cheval, and the Periya Paar. Fig. 3 is the scarlet spherical mass *Aulospongus tubulatus*, a Sponge in which the minute Polychæte worm *Polydora armata* lives as a commensal. Fig. 4 is the remarkable "umbrella" Sponge, *Phyllospongia holdsworthi*, which is said by the divers to be characteristic of the "Koddai Paar" to the west of the Cheval. It is, however, found also on various parts of the Cheval, Muttuvaratu, and Periya paars, and elsewhere.

Amongst Cœlenterates, corals are the most conspicuous and important forms. Living reefs composed of many common species compete successfully with the pearl oysters at many places and prevent the formation of beds, while solitary forms such as *Fungia* are found alive scattered over the sandy bottom on the Cheval and other paars. In some places there are great aggregations of *Heterocyathus aequicostatus* and *Heteropsammia michelini*, both of which have in their base commensal species of *Aspidosiphon* and of *Jousseaumia*. Many of the reef-building corals, such as species of *Madrepora*, *Porites*, *Pœcilopora*, *Montipora*, *Favia*, *Goniastrea*, *Galaxea*, and *Cœloria*, are also found growing over the shells of living oysters. This is especially the case on the Muttuvaratu Paar. *Turbinaria cinerascens* and *T. crater* are especially common on some parts of the northern paars.

Some of the fleshy Alcyoniidæ are very common on the coral reefs at the pearl banks, and form enormous colonies several feet in diameter. The Gorgonoid Alcyonaria are for the most part found in deeper water outside the pearl-bank plateau, but a few species such as *Juncella juncea* and *Suberogorgia suberosa* occur on the Cheval Paar.

One of the Hydroid Zoophytes, *Campanularia juncea*, Allm., which grows to a large size (Plate II., fig. 6), is especially characteristic of the East Cheval Paar. Another handsome species from the pearl banks is *Halicornaria insignis*, Allm. (Plate II., fig. 5).

Some of the Echinodermata are amongst the commonest and most conspicuous of

animals both on the oyster beds and on the sandy stretches between. The huge black trepang, *Holothuria atra*, and the flat urchins, *Clypeaster humilis* and *Laganum depressum*, eat their way through the sand, and the star-fishes, *Pentaceros lincki* (Plate I., fig. 1), *Luidea maculata*, and *Astropecten hemprichi* prowl over the surface and devastate the pearl oysters.

Amongst the worms, in addition to the numerous parasites that infest the oyster, there are two abundant species of *Polydora* that call for special mention—*P. hornelli*, found burrowing in the oyster shells, and *P. armata*, a commensal in the globular scarlet sponge, *Aulospongus tubulatus* (Plate II., fig. 3). Polyzoa are especially abundant, and are a factor of importance in the building up of the calcareous masses on the reefs and the paars—*Schizoporella viridis* may extend for several feet, and *Lepralia cucullata* is abundant, encrusting oyster shells, ascidians, sponges, and almost all other objects with its dark purple spots and patches.

Crustacea of various kinds abound, but so many species are represented that there seem to be no specially notable ones. The Alpheidæ are common, Pagurids are very abundant, and crabs, mostly of small size and many of them inconspicuous from their protective shapes and colouration, are found in every haul of the dredge.

In addition to common Gastropod and Lamellibranch shell-fish, there are several Opisthobranchs—notably *Philine aperta* and *Aplysia cornigera*—that congregate in great numbers in some parts of the Gulf of Manaar. *Pinna* is abundant in places and of large size. Species of *Pinaxia*, *Sistrum*, *Nassa*, and *Purpura* are found boring into the smaller pearl oysters, and the large "Chanks" (see Plate I., fig. 3, A, B, C, D) are of importance both as damaging the large oysters and also as constituting a fishery themselves. *Modiolus barbatus* (Plate I., fig. 2), from its habit of weaving entanglements, is another molluscan enemy of the younger pearl oysters.

The large simple Ascidian *Rhabdocynthia pallida* is abundant on some parts of the Cheval Paar. Several species of Amphioxus burrow in sand, the commonest on the Cheval and Periya paars being *Branchiostoma lanceolatum*, var. *belcheri* and *Asymmetron cingalense*. Over 200 species of fishes frequent the pearl banks, and many of these are carnivorous, including especially the file and the trigger fishes and the gigantic rays. In addition to the species that have been mentioned as especially common, characteristic, or important, there are enormous numbers of the smaller organisms belonging to many invertebrate groups that are found encrusting and attached to the shells of the older pearl oysters. Fig. 7 on Plate II. shows a photograph of such a "microcosm" from the Cheval Paar.

Such are the animate surroundings, including both friends and foes, amid which the pearl oyster habitually lives in the Gulf of Manaar, and seems, if left in comparative peace, able to hold its own in the struggle for existence; but the balance, as we have shown in previous parts of this report, is liable to be seriously disturbed by three all-powerful factors: devastating hordes of voracious fishes which come up from the deeper waters and leave crunched shells and torn byssus in their wake; storms,

currents, and over-washes of sand which may sweep away or bury a promising bed; and lastly man who comes periodically from above on his diving stones and clears the bank of its tens of millions of oysters, old and young. The carnivorous fishes and the monsoons cannot be controlled; but to show that much can be done by man to mitigate their influence, and to compensate for the decimation necessarily caused by his own operations, has been the chief object of the present Report.

EXPLANATION OF THE PLATES.

PLATE I.

Some Enemies of the Pearl Oyster.

Fig. 1. *Pentaceros lincki*, de Bl. Reduced to one-third natural size.
,, 2. *Modiolus barbatus*, Linn. The "Suran," in its nests or entanglements.
,, 3. A, B, C, D, the following four large Chanks, from left to right:—

A. *Murex ramosus*, Linn. The elephant chank.
B. *Fasciolaria trapezium* (Linn.). Chank.
C. *Turbinella pyrum*, Linn. The common chank.
D. *Turbinella rapa* (Linn.). The sacred chank—possibly only a form of the last species.

PLATE II.

Some Characteristic Animals of the Pearl Banks.

Fig. 1. *Petrosia testudinaria* (Lamk.). Reduced one-half.
,, 2. *Phakellia donnani* (Bowerb.). Nat. size. A, flabellate; B, cup-shaped form.
,, 3. *Aulospongus tubulatus* (Bowerb.). Nat size.
,, 4. *Phyllospongia holdsworthi* (Bowerb.). Reduced one-half.
,, 5. *Halicornaria insignis*, Allman. Reduced to one-fourth.
,, 6. *Campanularia juncea*, Allman. Reduced to one-third.
,, 7. A living pearl oyster, *Margaritifera vulgaris*, Schum., covered with many encrusting and adhering organisms; slightly reduced.

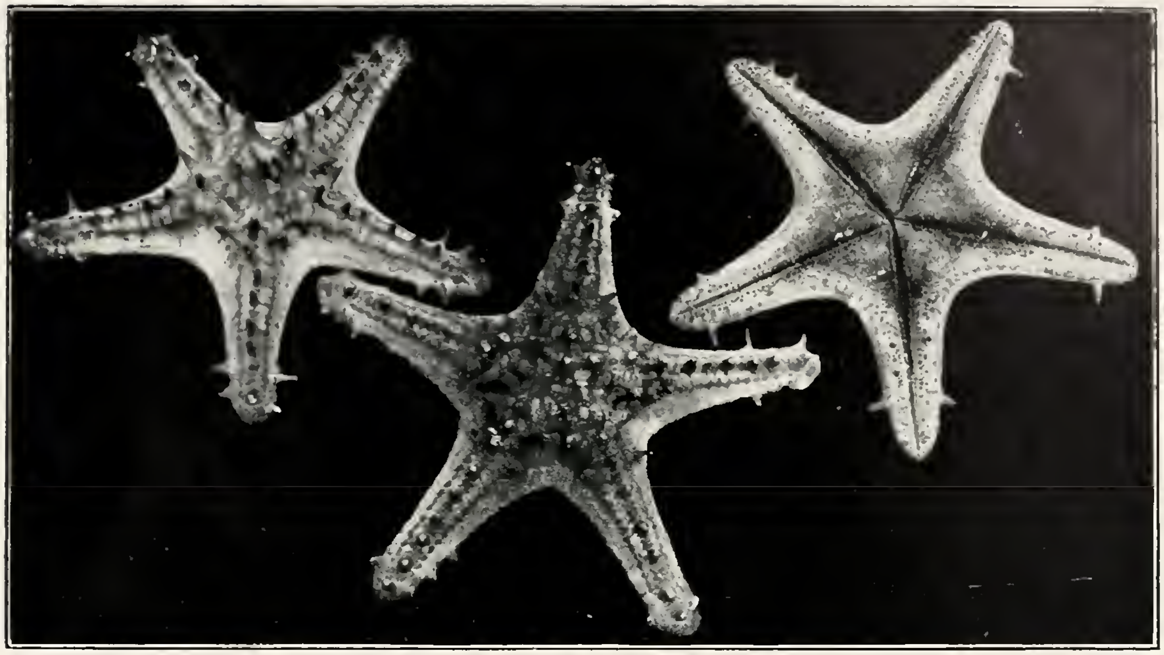


Fig. 1.

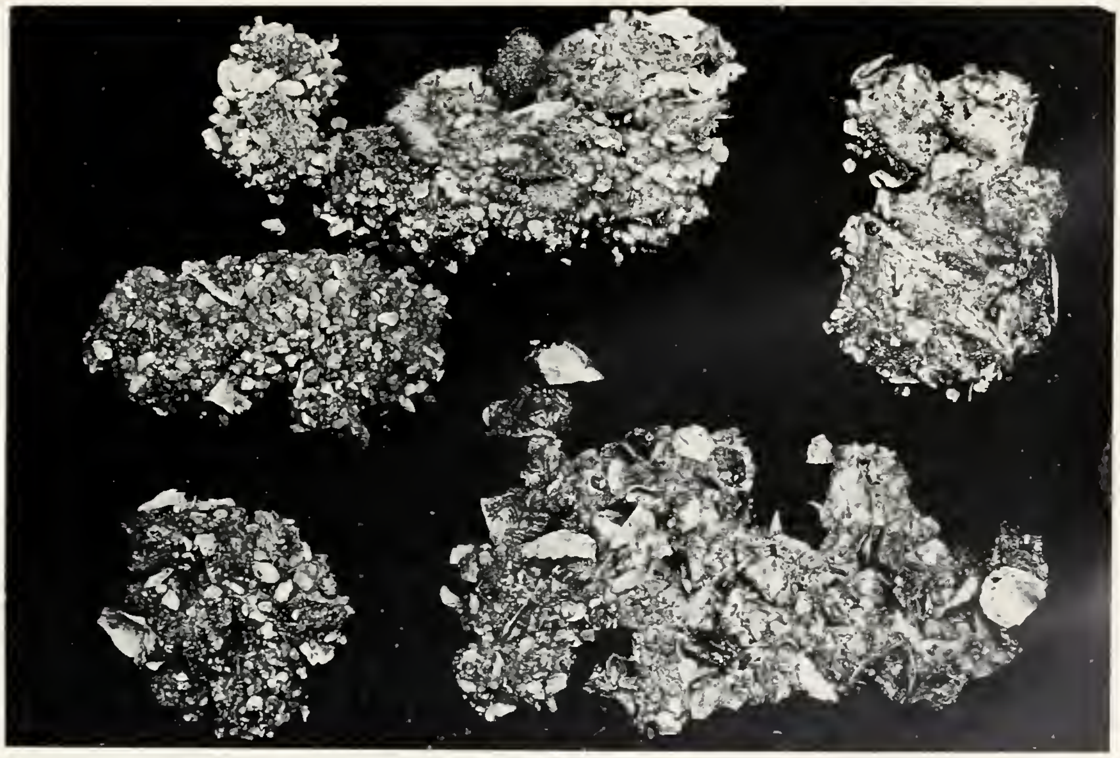


Fig. 2.

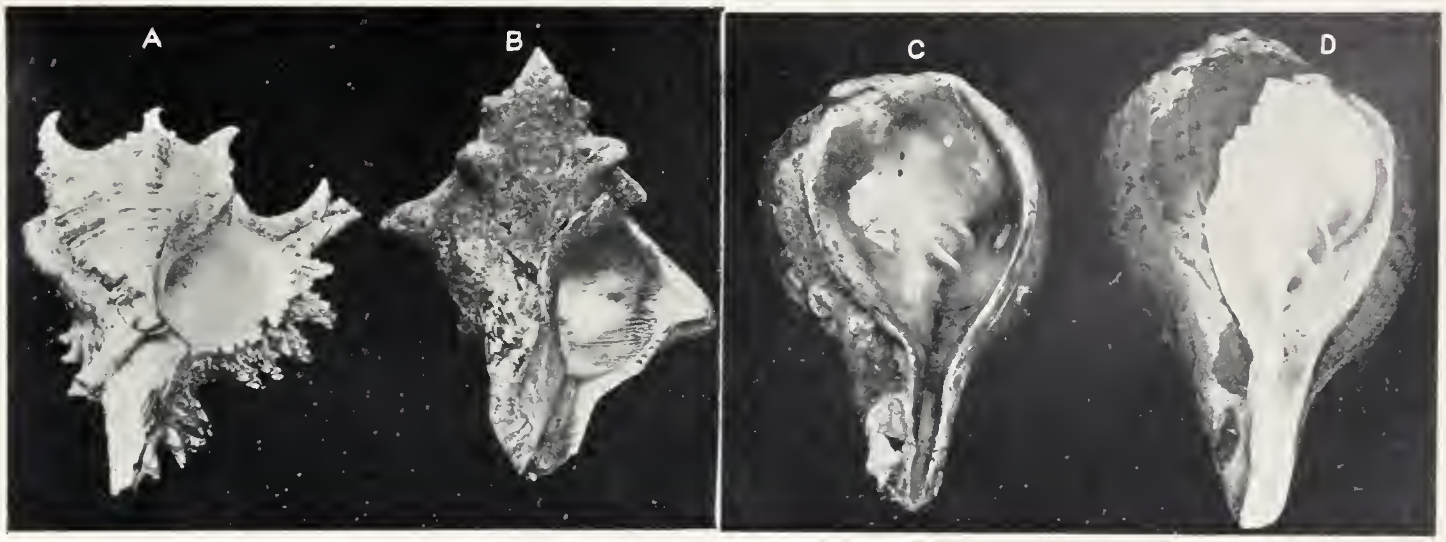


Fig. 3.

ENEMIES OF THE PEARL OYSTER.

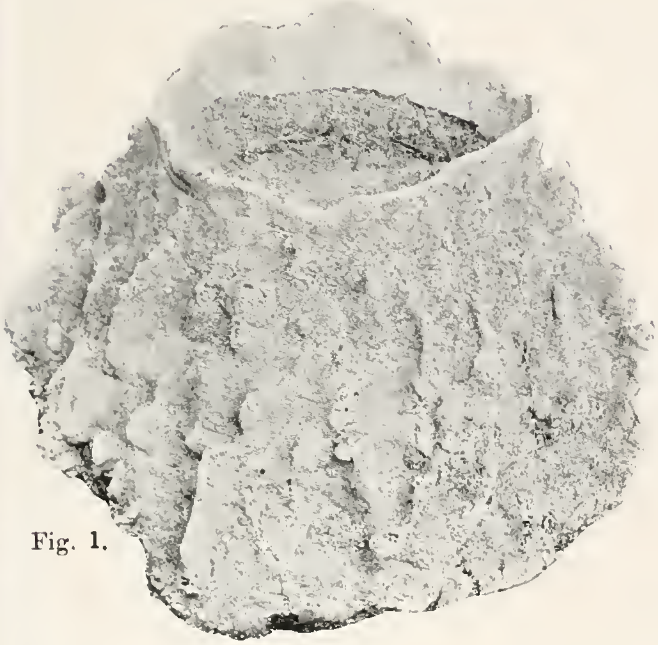


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 7.

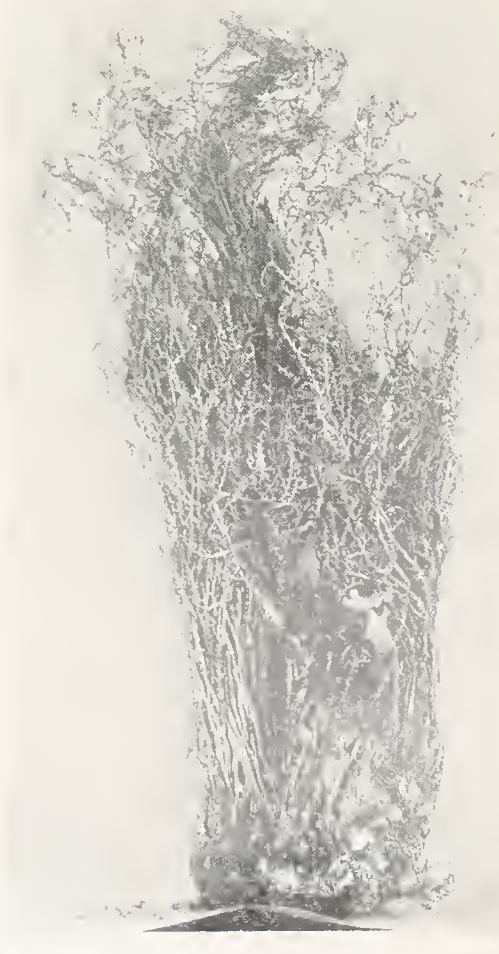


Fig. 6.

CHARACTERISTIC ANIMALS OF THE PEARL BANKS.

CORRECTIONS AND ADDITIONS.

PART I.—(LIFE HISTORY, &c.), p. 142, ll. 30, 31, 33, *for* "acres" *read* "sq. yards."

,, II.—(HYDROIDA), p. 119, ll. 17, 30, *for* "*Desmoeyphus*" *read* "*Desmoseyphus.*"

,, II.—(CRINOIDEA), p. 157, l. 20, *for* "*Antedon anceps*, CARPENTER," *read* "*Antedon bengalensis*, HARTLAUB."

,, II.—(CUMACEA), p. 175, l. 22, *for* "exopod" *read* "endopod."

,, II.—(CEPHALOPODA), p. 186, *et seq.*, *for* "*Polypus aeuleatus*" *read* "*Polypus horridus.*"

,, III.—(SPONGES), Professor DENDY adds the following records:—

(1) *Sycon raphanus*, var. *chevalensis*, n., characterised by spear-shaped ends to some of the dermal oxea. The species is recorded from Ceylon by HAECKEL.
(2) *Iotrochota baeulifera*, RIDLEY.—Palk Bay.
(3) *Spongelia fragilis*, variety.—Reef, Galle; several large colonies.
(4) *Spirastrella tentorioides*, DENDY.—A second specimen, confirming the characters given on p. 126.

,, III.—(ALCYONARIA), p. 317, l. 4, *for* "Plate III." *read* "Plate IV."

,, III.—(ALCYONARIA), p. 325, l. 2, *for* "cylindrical" *read* "quadrangular."

,, III.—(ALCYONARIA), p. 325, l. 14, *for* "the axis is round not square" *read* "the axis is quadrangular not cylindrical."

,, IV.—(MACRURA), pp. 65, 67, 76, 92, *for* "*Caradina*" *read* "*Caridina.*"

,, IV.—(MACRURA), pp. 66, 67, 79, 92, *for* "*Nauticaris grandirostris*, n. sp." *read* "*Saron gibberosus* (M. EDW.)."

,, IV.—(POLYZOA), p. 108, l. 25, *for* "his private collections," &c., *read* "the collection in the Univ. of Cambridge Zool. Museum."

,, IV.—(POLYZOA), p. 110, l. 8, *for* "*Membranipora favus*, HINCKS," *read* "*Membranipora normaniana*, D'ORB."

,, IV.—(POLYZOA), p. 110, l. 14, *for* "*Membranipora hastilis*, KIRKPATRICK," *read* "*Membranipora coronata*, HINCKS."

,, IV.—(POLYZOA), p. 110, l. 16, *for* "*Amphiblestrum cervicorne*, BUSK," *read* "*Amphiblestrum radicifera*, var. *intermedia*, KIRKP."

PART IV.—(POLYZOA), p. 113, l. 3, *for* "*Berenicea prominens*, LX. [= *Ch. brongniartii*]" *read* "*Chorizopora brongniartii* (AUD.)."

,, IV.—(POLYZOA), p. 114, l. 17, *for* "*ceeilia*" *read* "*cecilii*."

,, IV.—(POLYZOA), p. 116, l. 5, *for* "*avieularis*, n. sp.," *read* "*inelusa*, n. sp." [name changed to avoid possible confusion with *Cellepora avieularis*].

,, IV.—(POLYZOA), pp. 117, 118, *for* "*Rhyncopora*" *read* "*Rhynehozoon*."

,, IV.—(POLYZOA), p. 121, l. 6, *for* "*nitida*, n. sp." *read* "*adhaerens*, n. sp." [to avoid possible confusion with *Membraniporella nitida*, JOHNST.].

,, IV.—(POLYZOA), p. 122, l. 18, *for* "*fissa*, n. sp." *read* "*gallensis*, n. sp." [to avoid possible confusion with *Schizotheca fissa*, BK.].

,, IV.—Add to POLYZOA: *Alcyonidium mytili*, DALYELL.—Galle.

,, IV.—(SOLITARY CORALS), p. 192, Professor BOURNE adds:—

A fixed specimen of *Cyathotrochus herdmani* has been found (off Galle, 100 fathoms). This necessitates the following correction in the diagnosis of the genus:—*For* "Corallum simple, free, without a trace of adherence" *read* "Corallum simple, free or fixed by a narrow base, the basal scar completely filled up in the free forms so as to form a short laterally compressed cone."

PART IV.—(POLYCHÆTA), p. 248, l. 4, *for* "1887" *read* "1878."

,, IV.—(POLYCHÆTA), p. 281, l. 29, *for* "*acquabilis*" *read* "*aequabilis*."

,, IV.—(POLYCHÆTA), Plate VI., fig. 139.—An extra bundle of setæ has been inserted by the lithographer on the right side in front of the normal row of fascicles.

,, IV.—(POLYCHÆTA), add: A few additional forms have been examined by Mr. ARNOLD T. WATSON, who reports the following:—

(1) *Palmyra herdmani*, n. sp.—Found in the tube of the large Foraminifer, *Ramulina herdmani*, from Galle. The characters are: Head, darkish brown and iridescent, distinctly globular (instead of more or less rectangular, or an oval placed transversely to the body). Eye-spots four, light brown, oval; posterior pair contiguous and situate slightly behind apex of the head; anterior pair just beneath a very short, stumpy, cone-like, unpaired tentacle. (Immediately behind the head was a brown, oval capsule, or caruncle, which may possibly have been adventitious.) Head and caruncle almost completely hidden beneath the pale yellow paleæ. Back completely covered, the inner edges of opposite flabella overlapping in the middle. No elytra apparent. Dorsal paleæ serrated on edge, about 21 in the largest flabella, almost linear at the outer edge of flabellum, gradually becoming falciform towards the centre. Both dorsal paleæ and ventral serrated compound setæ somewhat similar to those of *Palmyra debilis*, GRUBE, but the appendix is slender and very much longer. Ventral cirri springing from a basal tubercle on neuropodial lobe and bearing a

reddish-brown band especially in the anterior segments. Cirri, both ventral and dorsal, tapering away to a slender filament. Specimen, a fragment 3·5 millims. long, 1 millim. broad over setæ, consisted of the anterior 17 pairs of parapodia only.

(2) *Ascidicolous Nereid from Galle.*—This worm, the identity of which has not yet been satisfactorily determined (though apparently allied to *Nereis vexillosa*, GRUBE), was found in the crevices of an Ascidian. The specimen is 22·5 millims. long, 3·5 millims. broad over the setæ, and consists of the head and anterior 64 segments only, the hinder part of the body being in course of regeneration. The head differs greatly from that of *N. vexillosa* and is very remarkable, being rather longer than broad and almost rectangular in form. It is dark brown and iridescent, as are also the succeeding 12 segments. Eyes large and black, the anterior pair before and the posterior pair just behind the bases of the longest cirri. Tentacles widely separated and half length of the head. Longest tentacular cirrus about twice as long as head, others much shorter. Palps large brown bases with pale tips. First four body segments twice as long as the succeeding ones. The proboscis being retracted, the paragnaths have not yet been examined. The setæ are somewhat similar to those of *Nereis melanocephala*, their general distribution being two slender spinigers in each dorsal lobe, and two or three spinigers, accompanied by five to seven stout setæ with pectinate falces, in each ventral lobe. The outline of the enlarged dorsal ligules of the posterior parapodia differs greatly from the figures of *N. vexillosa* given by GRUBE and EHLERS; the cirrus, moreover, is long and blade-like instead of filiform. This is probably a new species.

(3) *Brown, Parchment-like Branched Tube of one of the Eunieidæ.*—The main trunk 11 millims. calibre, 70 millims. long, with two short branches from one side. The terminal half of trunk sinuous, much like the tube of *Eunice tibiana*, EHLERS, with numerous openings in corresponding positions. The lower half of tube is partially enveloped by a compound Ascidian, *Leptoclinum* sp., the colony being perforated at intervals for openings into the tube. No worm accompanied the specimen.

PART V.—Add the following list of ACTINIARIA identified by Mr. T. SOUTHWELL:—

Cerianthus sp.—Tampalakam, Trincomalee.

Zoanthus shackletoni, HADD. and DUER.—Reef Galle and Gulf of Manaar.

Zoanthus (? n. sp.).—Reef Galle.

Isaurus duchassaigni (ANDRES).—Coral reef, Gulf of Manaar.

Gemmaria variabilis, DUERDEN.—Reef Galle.

Palythoa tuberculosa, KLUNZ.—Reef Galle.

Sphenopus marsupialis, STEENSTR.—Station LVIII., 9 to 26 fathoms, and elsewhere in Gulf of Manaar.

Halcampa sp.—Tampalakam, Trincomalee.

Sagartia sp.—Reef Galle.

Phellia sp.—Cheval Paar, Gulf of Manaar.

Calliactis sp.—Pearl banks, Gulf of Manaar.

Chondractinia digitata (Müller).—Station XX., 11 to 13 fathoms, Trincomalee.

Actinauge sp. (? n. sp.).—West of Periya Paar.

Another form, not identified, from Gulf of Manaar, shallow water.

Several of the unidentified species in the above list are in all probability new to science. Out of these 14 species 11 are new records to Ceylon, those previously known being *Zoanthus shackletoni*, *Palythoa tuberculosa* and *Sphenopus marsupialis*.

The only specimens in the Ceylon Collection that now remain unidentified and unexamined, so far as I am aware, are about half a dozen Enteropneusta, belonging apparently to three species.—W. A. H.

Our deck laboratory on the "Rangasami-Poravi."

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